AIRCRAFT AND MISSILES MANUFACTURING

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JUNE 1959

DESIGN
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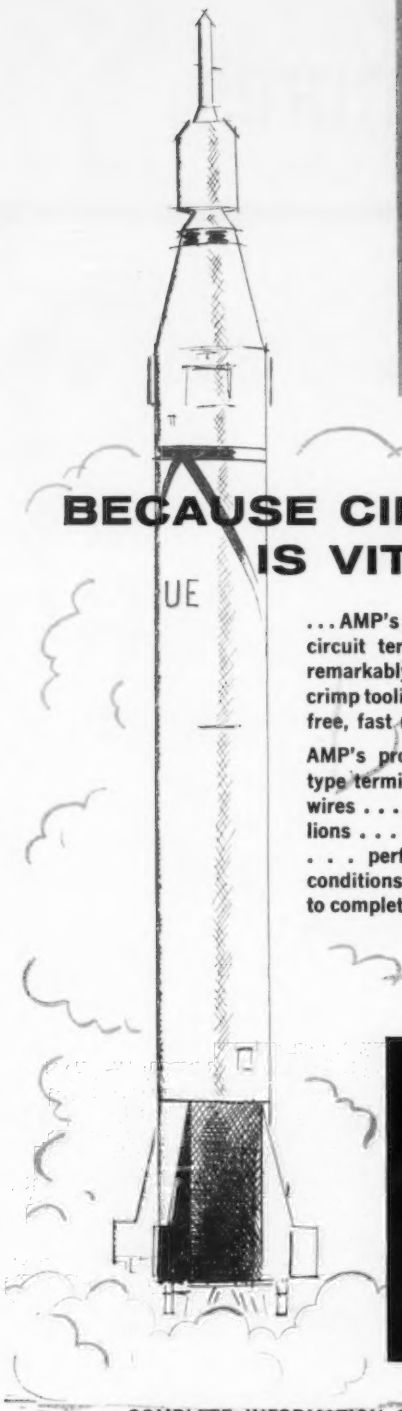

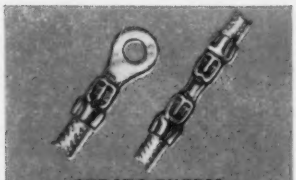

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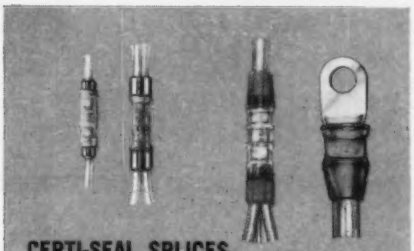

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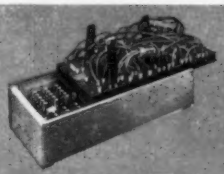

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PAGE

6 X-15–the airframe

14 X-15–the material

20 X-15–the engine

26 X-15–flight instruments

32 X-15–hydraulic seals

42 X-15–a prodigious project

46 optics in the wind tunnel

THE COVER STORY

During the coming months a lone man will make successive attempts to peek beyond the fringe of the Earth's life sustaining atmosphere. By doing this he will establish the first toe hold for the generations to follow him. The vast human effort behind this undertaking may perhaps indicate the effort required for more ambitious plans, and motivate greater scientific cooperation on a world-wide scale.

departments

PAGE		PAGE	
5	editorial orbit	69	men on the move
49	materials and components	73	worth asking for
57	new for production	88	your date book

industry notes

PAGE		PAGE	
77	X-15: the flight	86	terra-scope
79	outlook on materials		X-15 guidance details
83	facilities		X-15 survival suit
84	contracts		X-15 approximate schedule

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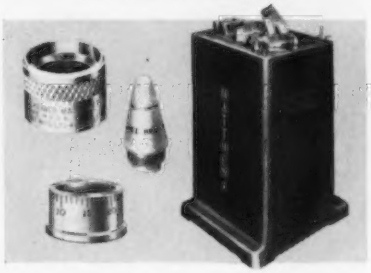

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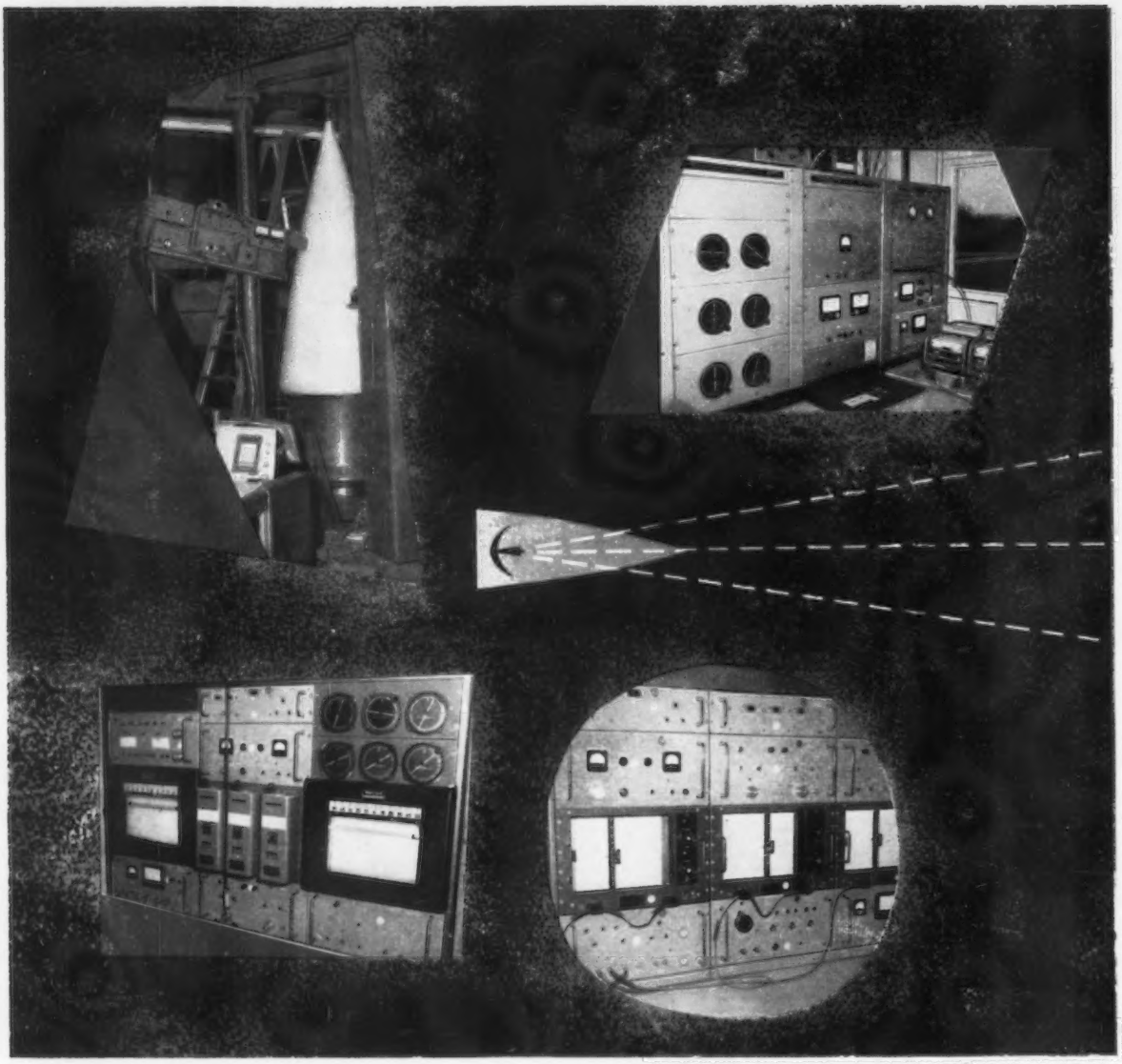

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X-15—evolutionary not revolutionary

Much excitement has been stirred up over man's attempt to break into space and return. Manned missile and revolutionary are terms pinned on the X-15.

It is a little of both, and yet it is neither. The "15" is an aerodynamically sound craft incorporating proved principles of powered flight. But, there will be portions of X-15 flights where 50 years of accumulated knowledge in aerodynamics will not apply.

Some of its design characteristics are outgrowths of the modern high-mach aircraft. Its power is just a little less than that of most present day missiles used for space exploration. Materials used to produce it are not foreign to our current technology. Production processes have not been altered to any great extent.

Certainly, important improvements have been made during the long and tedious design, testing and production phases. This is true in any significant development program.

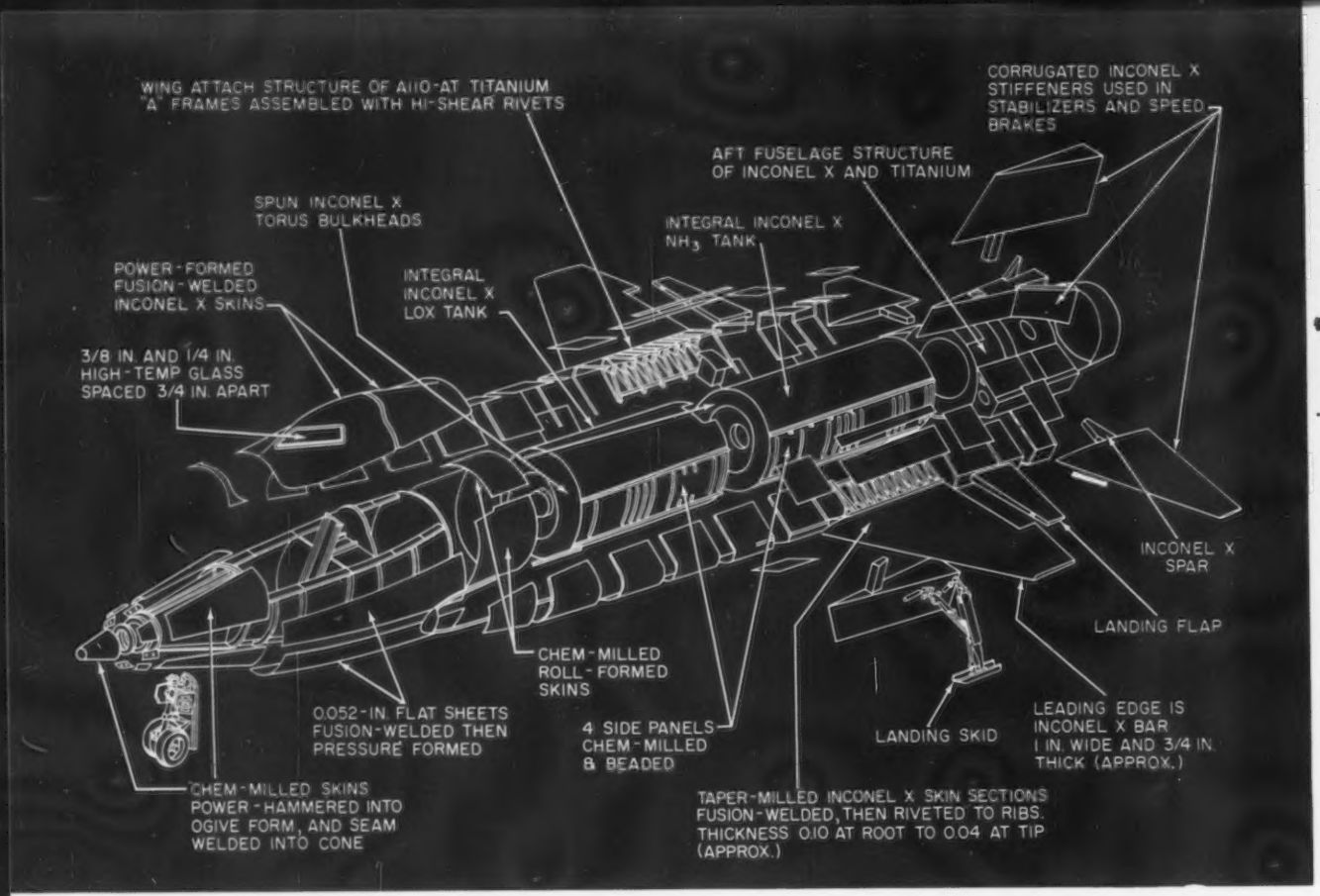
What we have is a well-designed vehicle capable of flying higher and faster than current production planes. This is, in a way, the same as the difference between the F-51 and the F-104.

The "15" has been designed for a particular mission—"fringe-of-space-research." It was built with the materials and processes of today. This is important. Its development represents a high degree of evolution; it is not revolutionary.

What the industry lacked, and still lacks, is an electronic computer, in a small package, capable of the performance of a highly-trained human brain. If such an item were available, it would have been used to look for the answers we now seek in "manned space-flight." It isn't available. Thus, man must program the flight activities of the ship. Man has choice of the mission during operation. He has the option of complete abortion. Man is the complex computer.

Though some of the industry's most highly refined instrumentation has been incorporated in X-15, human judgment and "seat of the pants" flying will play a major part in bringing the bird home. Certainly, this aspect of flight hasn't changed.

Editor


WING ATTACH STRUCTURE OF A110-AT TITANIUM "A" FRAMES ASSEMBLED WITH HI-SHEAR RIVETS
CORRUGATED INCONEL X STIFFENERS USED IN STABILIZERS AND SPEED BRAKES
AFT FUSELAGE STRUCTURE OF INCONEL X AND TITANIUM
SPUN INCONEL X TORUS BULKHEADS
INTEGRAL INCONEL X NH_3 TANK
POWER-FORMED FUSION-WELDED INCONEL X SKINS
INTEGRAL INCONEL X LOX TANK
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LANDING FLAP
CHEM-MILLED ROLL-FORMED SKINS
0.052-IN. FLAT SHEETS FUSION-WELDED THEN PRESSURE FORMED
4 SIDE PANELS CHEM-MILLED & BEADED
LANDING SKID
LEADING EDGE IS INCONEL X BAR 1 IN. WIDE AND 3/4 IN. THICK (APPROX.)
CHEM-MILLED SKINS POWER-HAMMERED INTO OGIVE FORM, AND SEAM WELDED INTO CONE
TAPER-MILLED INCONEL X SKIN SECTIONS FUSION-WELDED, THEN RIVETED TO RIBS. THICKNESS 0.10 AT ROOT TO 0.04 AT TIP (APPROX.)

X-15—the airframe

fuselage designed in four major segments, attach points on integral tankage serve as main wing-to-fuselage juncture

by J. Philip Geddes

By North American Aviation's definition X-15 is a research vehicle, "to obtain knowledge of actual flight conditions beyond the Earth's atmosphere, aerodynamic heating and heat transfer, and the measurement of heat on structural components." Flight conditions include control, re-entry, and human-factor problems. But, behind the spectacular mission of the X-15, lies an expanse of remarkable manufacturing achievement.

North American is contracted to build a total of three X-15's. Within the contract there is no time allowed to develop and gradually incorporate each departure from conventional design and fabrication practice into a production series. All the unusual design features necessary for X-15's research function, are built directly into the three aircraft. The overall departure from traditional design is reflected by the extensive structural welding used; about 65 per cent of the X-15 airframe is welded and 35 per cent fastened. The X-15 is designed to tolerate torturing effects from experiencing —300°F and 1200°F simultaneously.

In choosing a material for the X-15 skin, in addition to normal factors such as strength, modulus of elasticity, and strength-to-weight

ratio; factors such as thermal conductivity, coefficient of thermal expansion, surface emissivity, oxidation-resistance, and temperature dependence properties were considered (AMM May, 1958). Structural integrity at high temperatures is preserved by using Inconel X in 100 per cent of the skins, fastened to Inconel X and A110-AT titanium ribs, stiffeners and frames. Aluminum alloy is also used where heat is no factor.

Inconel X forming characteristics are similar to those of stainless steel in the annealed condition; no special machines were required for forming. However, special tools were designed to adapt conventional machines to make parts such as the flanged, formed corrugation used in the stabilizers, speed brake doors and surface control-beams.

These stabilizer frames required extremely accurate development of material prior to forming. Tools adapted to power brake and punch press had to be built much more precisely because of the thin gauges of material used. It would have been too costly to fabricate tooling capable of building finished parts; therefore, tools were made to do certain operations on all of the frames and the remainder of the fabrication was accomplished on benches by hand. The greatest difficulty was encountered in the extensive forming and the thin gauges involved.

Forming of A-110 titanium sheet proved also difficult. The major problems here were due to hot forming; higher temperatures and accurate temperature-control were needed. Form blocks with wiper plates were used on many of the difficult parts. The tools and the material were heated to 1200°F and formed on conventional equipment such as arbor press, power brake, punch press, hydro-press. High-pressure lines, on the ship, were brazed at joints to eliminate leakage possibilities arising from threaded connections.

To meet the tight manufacturing schedule greater effort was made to improvise rather than develop conventional "production" methods.

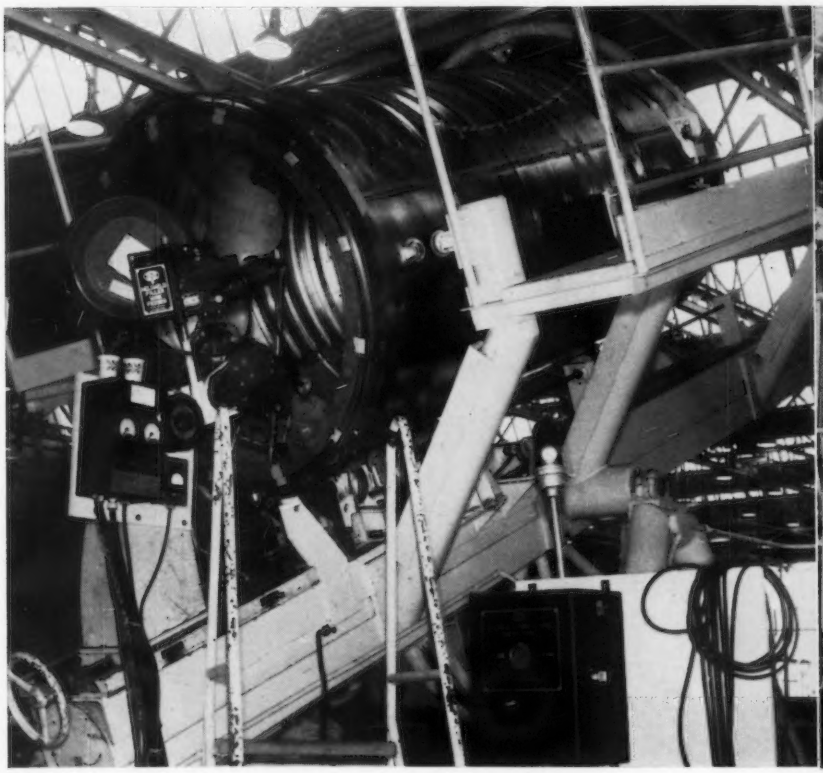
The direct costs for the project amounted to $116.1 million for the Air Force, and 5.4 million for the Navy.

Building the Fuselage

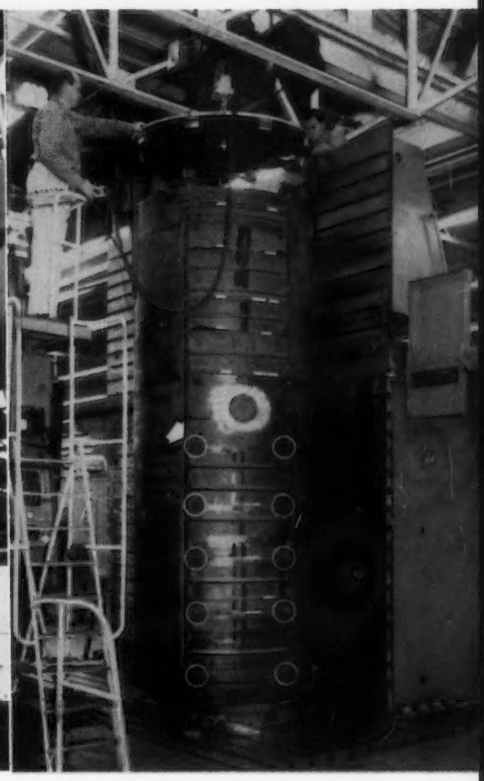
The fuselage is built in four major sections; forward fuselage, forward tank (lox), aft tank (ammonia), and aft fuselage.

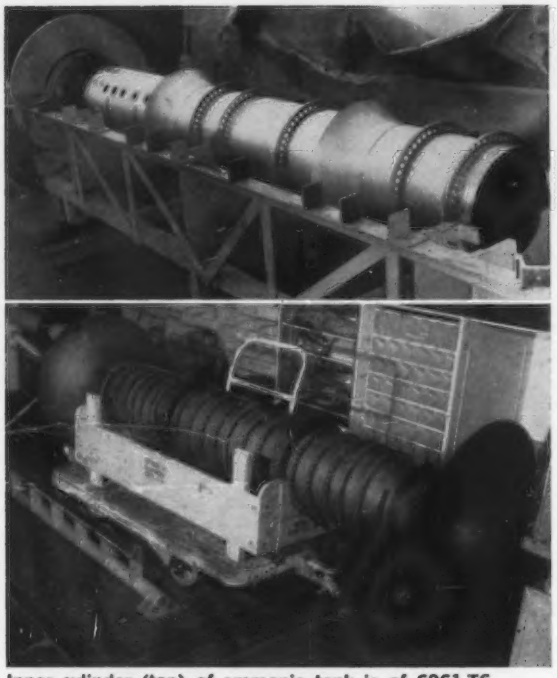
Forward fuselage structure consists of the nose cone (less nose-boom assembly) pilot's com-

Lox-tank shell is shown in circumferential fusion-weld jig; tank end strap has been positioned. Rotary-weld fixture is tilted to puddle the weld.



Ammonia tank is being positioned in Pratt & Whitney Keller end mill, to machine wing "A" frame attach fittings (shown encircled).





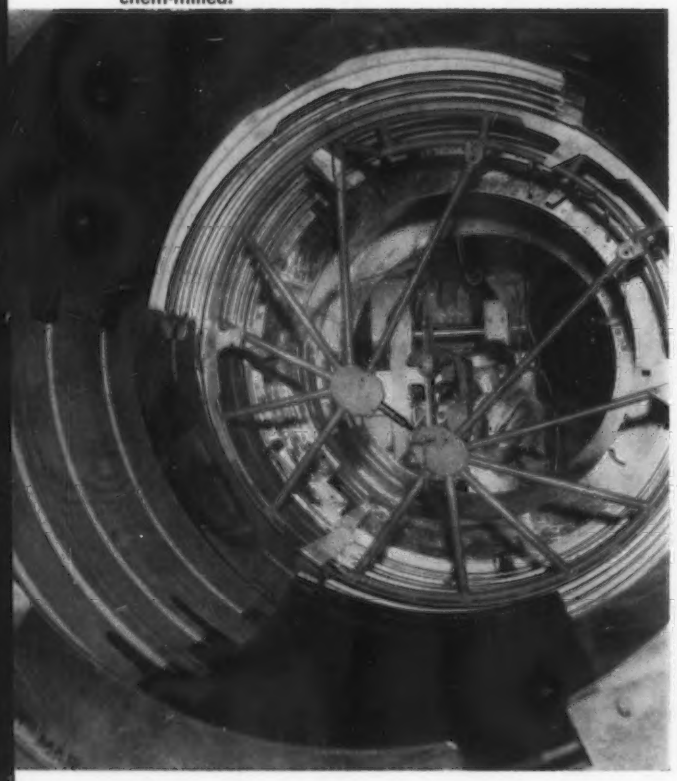
Inner cylinder (top) of ammonia tank is of 6061-T6 aluminum alloy, chem-milled after longitudinal machine fusion-welding. Details are spot and seam-welded to cylinder. Inner cylinder (below) of lox tank, with tori, is of Inconel X. Assembly is heat treated after completion.

the airframe . . . continued

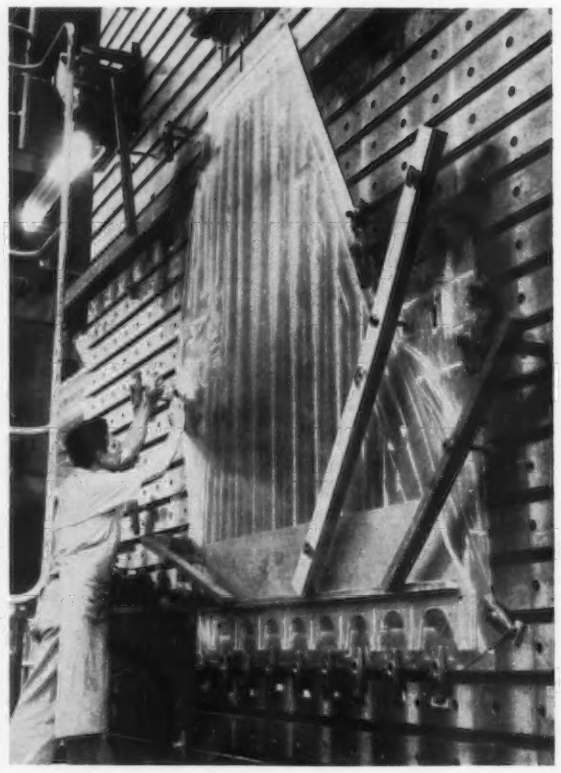
partment, and electronics bay. The forward fuselage is made up from three major skin sections: a first ogive section, a second ogive section, and a cylindrical section, all with Inconel X skins.

The first ogive section is made of five chem-milled skins power-hammered into an ogive form, spot and seam weleded into a cone-shaped assembly. The second section, designed to contain the pilot's compartment, is made from four 0.052-in. flat sheets trimmed to a predetermined cone shape, then machine fusion-welded together. This cone section is then placed in a bulge form die and pressure formed under 350-400 psig air

Ammonia tank shell has internal details spot-welded. Spider mandrel keeps cylindrical shape during spot and seam welding. Four quarter-skin panels are of 0.065 Inconel X; two side panels are Hydroformed and chem-milled.



Inconel X wing skin panel is sculptured on a Keller machine.



pressure, to produce the ogive shape. The aft section of the forward skins is rolled to form a cylinder corresponding in cross section to the adjoining lox tank in an assembly weld jig. A series of short longerons are then welded into place in the cylindrical section.

These fuselage sections are welded together to make one continuous shell-like skin surface unbroken by cutouts from the attach point of the forward nose cone to the forward lox tank.

Heat Treating the Forward Fuselage

After welding the cone and cylinder assemblies, retained in fixtures, these are stress-relieved and heat treated. Stress relieving and heat treating for all X-15 structures are carried out, wherever possible, in vacuum or controlled-atmosphere furnaces. Pretreat coating, to prevent oxidation of surfaces, is required if normal-atmosphere furnace is used. Treatment consists of heating assembly to 1625°F, dropping the temperature to 1325°F within a 15-min period, and soaking at 1325°F for ten hr. Welds are X-rayed before and after this process.

After heat treating, the nose ogive and ogive cylinder, which together make up the forward fuselage section, are located in the forward fuselage jig. The pilot's compartment, electronics bay, and access doors are then cut out. Cutouts are made with spiral reamers, special nibblers, and small high-speed grinding wheels. Titanium frames, longerons, and stiffeners can then be located and riveted to the shells.

The structure of the forward fuselage is completed by fastening the two forward assemblies together with monel rivets and Inconel X screws.

Insulation against heat generated on the outside skin is provided by laminations of aluminum foil and glass wool, placed behind an aluminum inner-skin or liner running the complete length of the forward fuselage to the nose cone.

The fabrication sequence for the forward fuselage is reversed from the accepted way of manufacturing fuselage structure, in that skinning is first, inner structure second.

Fuselage Tanks

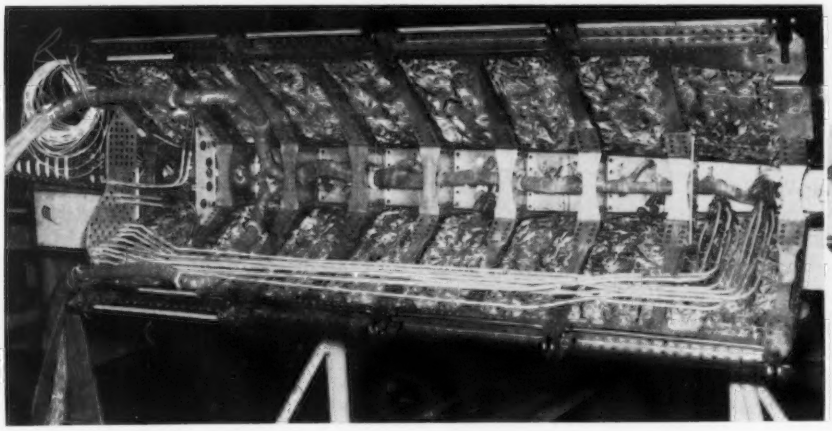
The section of the fuselage behind the electronics bay to the horizontal stabilizers is made of two separate tanks. The forward tank, approximately 10 ft long, for lox, and the aft tank, approximately 12 ft long, for liquid ammonia. A 14½-in. diam tunnel runs end to end through the center of each tank.

A high-pressure helium vessel, 14 in. in diam and 96 in. long, fits into the tunnel of the forward tank. The corresponding tunnel in the rear tank is not sealed off from the surrounding tank, and fills with fuel flowing through portholes in the tunnel walls. As in several other stages of construction closeout sequences are important as there is no access to the tunnel or baffled compartments after final assembly. Both tanks are built separately by the same method.

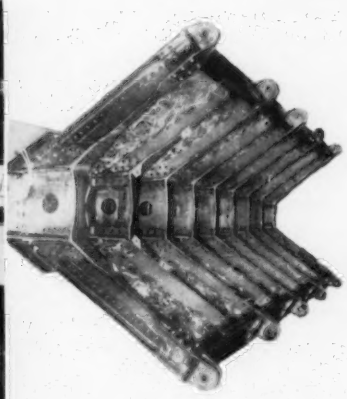
Four Inconel X skins are butt fusion-welded together to form each tank shell. To these cylinders, details such as external and internal stiffeners, installation brackets and torus bulkheads are spot and seam-welded into position.

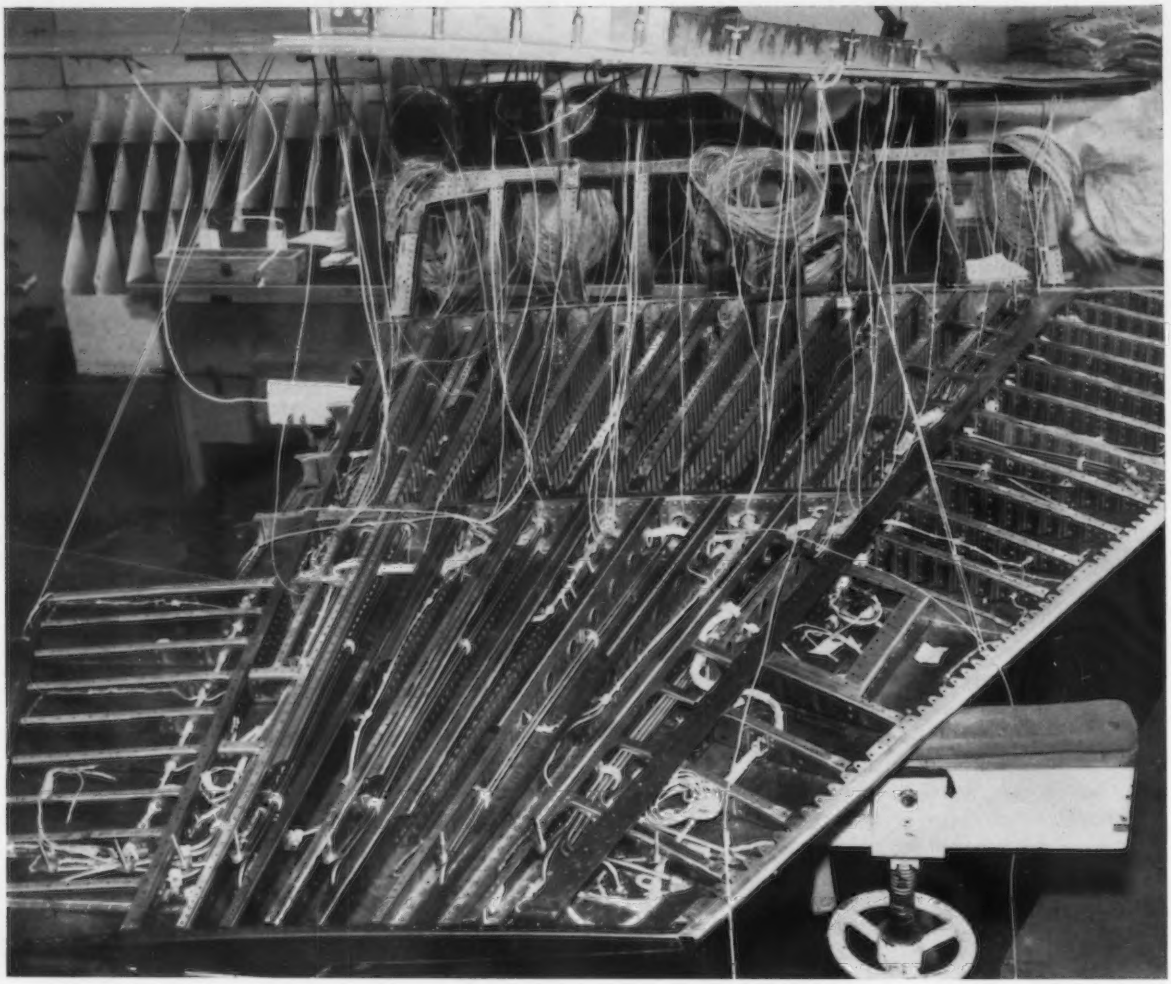
The tank torus bulkheads are made of Inconel X by spinning. Since no large blanks were available, these were made by welding segments together. However, initially the welds cracked

Wing "A" frame tunnel reveals insulation blanketing used to protect lines between front and rear fuselage. Extensive instrumentation wiring, from wing, is gathered into harnesses.



Wing "A" frame attach structure is assembled with 17-7PH stainless steel, interference fit Hi-Shear rivets. The structure is made of A110-AT titanium.





Right-wing instrumentation pickoffs are seen in place. Note blunt leading-edge heat-sink bar, extensive use of corrugated stiffeners on titanium structure. Upper skins, shown suspended above, closes out wing, and is riveted on by high-temperature, blind Cherry rivets.

the airframe . . . continued

during spinning operation. This was overcome by precision milling and roll planishing the welds before spinning. Good results were obtained by spinning in stages, on brake-down blocks; annealing was used after each stage to overcome work-hardening. Wing fittings are fusion-welded to the aft tank, then longerons fusion-welded to both tanks while still in separate sections.

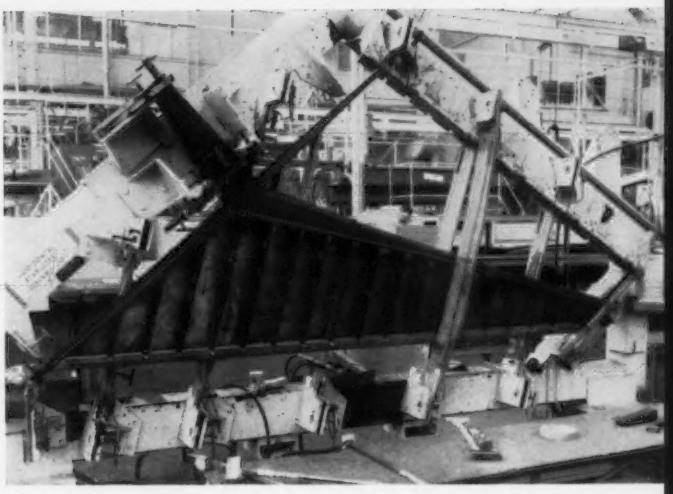
Fuel-volume distribution in the tanks is controlled by dividing each tank into three compartments with two aluminum bulkhead separations mounted between the inner tunnel and the outer shell. Final assembly on the tanks consists of welding the tank torus end assemblies together, followed by installation of the internal-structural frames and compartment bulkheads. In the latter stage, the operator installing the bulkheads works out towards a single closeout hole, sealing as he goes. Prior to closing out each tank, the inter-bay fuel-transfer lines are installed. Once the closeout hole is welded in, there is no further access to the interior. Each tank is tested by filling with water (de-ionized to prevent corrosion) and pressurized to 95 psig. After pressure test the tanks are oven-dried at 210°F while dry nitrogen is circulated in the interior.

Aft Fuselage

The aft fuselage is of Inconel X and titanium construction; the only radical departure from conventional practice being in the manner of assembling structural frames. Aft fuselage frames are made from several titanium segments welded together. Gussets and angles are in turn welded to the frames. A large percentage of the aft-fuselage outer-skin consists of Inconel X sheets

stiffened with spot and seam-welded, inner-beaded panel assemblies fastened to the frames with high-temperature screws. Most fairings are of similar construction using 0.012 to 0.020 in. Inconel X skins.

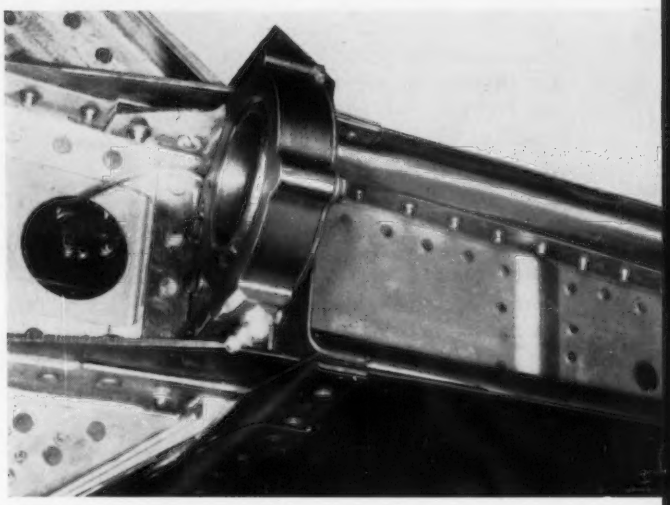
Beaded liners on the fairings and rear skins reinforce the panels sufficiently to resist buckling due to thermal expansion between the hot outside surface and cooler inside skin surfaces.



Horizontal stabilizer, seen in assembly jig, incorporates all-welded main-spar and control horn.

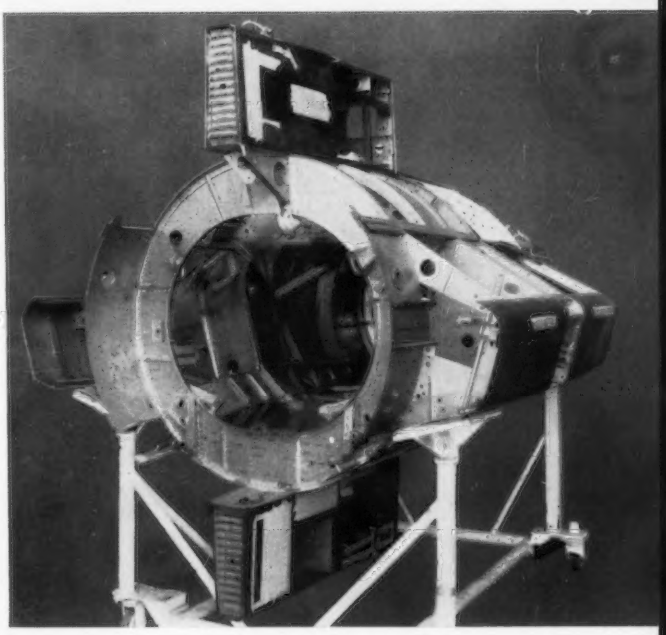
Wing

The five per cent thick symmetrical wing (max. chord thickness about 6½ in.) sweeps back 25 deg from a root-chord of 179 in. to 36 in. tip. The wing is of multispar structure with taper-milled Inconel X skins (each skin consisting of spanwise sections fusion-welded together) approx 0.100 in. thick at root tapering to 0.040 in. at tip. There are two span-length spars: the front supports the leading-edge assembly, and the rear a short trailing edge and flap attachment fittings—there are no ailerons on the X-15.



Landing flap fitting and wing skin are attached to rear spar with Hi-Shear rivets. Lightening hole at left is in aft face of right-hand "A" frame assembly.

The wing leading-edge is a rounded blunt, uniform-section, solid Inconel X bar (about 1 in. wide and ¾ in. thick) which acts as a heat sink. The upper and lower leading-edge-section skins rivet spanwise to this heat-sink bar. The leading-edge heat-sink bar is cut into five sections riveted to the leading-edge skins with 0.070-in. gaps between each section for thermal expansion. Wing-to-fuselage attachments are made at a series of five "A" frames riveted into the multispar structure.



Fuselage rear, which will house rocket engine, has an internal structure of Inconel X and titanium; skin is of Inconel X. Titanium frame sections are welded together to save weight.

The leg ends of these "A" frames form 10 attach fittings through which the wings bolt to the fuselage.

During assembly, a series of strain gages, thermocouples and pressure pickups are built into the right wing. Once the upper skin is riveted in place with blind, high-temperature Cherry rivets there is no further access to the instrumentation wiring or tubing.

Horizontal Stabilizer

The all-movable horizontal stabilizer is built around a heavy, welded box-beam assembly, part of which extends to form a center spar. This

spar has a corrugated Inconel X web to which a machined Inconel X cap is welded.

Corrugated Inconel X rib-like stiffeners, 0.008 to 0.063 in., are used extensively in both the horizontal stabilizer, speed brakes and vertical stabilizer. As on the wing, the horizontal stabilizer uses a blunt multi-section leading-edge heat-sink.

The leading edge is a single, milled sheet, folded symmetrically with a tapered airfoil section. Rather than machine a solid Inconel X heat-sink bar to fit within the folded skin, an economical alternative was used by filling-in the leading edge with number 139 Inconel X electrode weld. A length was partially welded, then the process repeated until a heat-sink bar, tapering from ½ to ¼ in. was filled along the complete leading edge. The weld-filling technique was perfected to the point where on the last stabilizer made, the bow along the 11-ft leading edge did not exceed ½ in. Bow on the leading edge is straightened out before riveting to main spar cap.

Four chordwise 0.070-in. thermal-expansion slots in the leading edge provide space for thermal expansion.

Vertical Stabilizers

The vertical stabilizers are of corrugated-web box-construction, with movable outer and fixed inner stub-sections. The under fuselage movable outer section is jettisoned before landing for ground clearance. Four speed-brake panels fit flush to the two fixed stabilizer stub sections, forming two "Vs" into the airstream when opened.

The heat-sink leading-edge for the vertical stabilizer, being of constant radius, is made from a machined Inconel X bar. The machined skins form the leading-edge lap-weld directly onto this bar. The leading edge is cut into three sections on the upper stabilizer and two on lower. These sections are riveted to the forward beam with 0.70-in. expansion space left between each section.

The main spars for the movable sections project as torque boxes which insert into aft fuselage. On the lower stabilizer the torque box remains in the fuselage when the lower movable section is jettisoned using explosive bolts.

In high-stress areas in both the horizontal and vertical stabilizers, hard A286 cres rivets are driven red hot. The rivets are induction heated to cherry red and driven by an automatic Zephr Tool sequencing machine.

Speed Brakes

The four speed brakes are of welded construction with corrugated stiffeners. A beaded closure-skin rivets onto the basic weld assembly. Thermal expansion plus airloads in flight result in two inch deflection about the hinge point.

Canopy

The canopy is made from three power-formed fusion-welded Inconel X skins. The windows are of high-temperature plate-glass in two layers, ⅜ and ¼-in. thick spaced ¾ in. apart.

Landing Gear

X-15 uses a free-fall nose gear with ballistic booster. The two aft-fuselage Inconel X skids are also free fall. Skids and nose gear employ conventional shock struts. A special ground handling dolly clipped to the aft fuselage is used in conjunction with the swivelling nose-wheel to provide easy ground-handling.

Welding

Machine welding is used extensively throughout the X-15. Weld preparation in the following sequence was found to be very important for good results:

1. Butt joints were draw-filed and all file scratches removed by polishing with a flat emery board.
2. Fine emery was used to remove all surface oxide ¼ in. back from weld line.
3. Weld areas were washed with ethyl acetate then vacuumed to remove all traces of fuzz.
4. Care was taken not to touch the weld areas after washing prior to welding, even to the point of not allowing the parts to touch the welding fixtures.

Successful manual welds which passed 100 per cent X-ray inspection came from the following:

1. Buffing weld area with stainless steel brush, cleaning with naphtha, and drying with a good grade of tissue or high grade clean cloth.
2. Anticipating high shrinkage on welds.
3. Protecting from oxidation on both sides by heli-arc welding with manual follow-up cap on other side.
4. Anticipating warpage.

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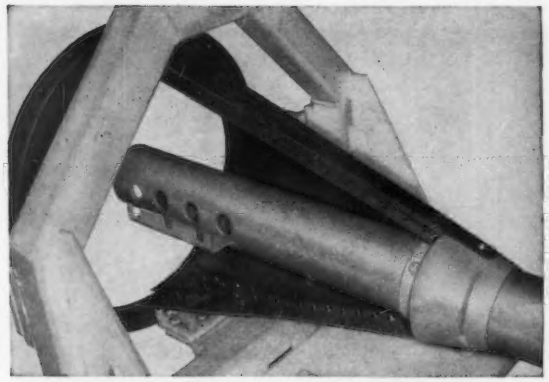
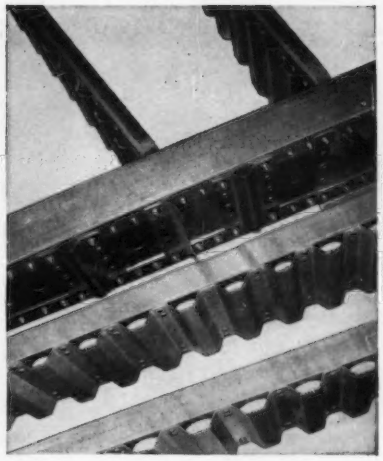


NOSE CONE SPLICE JOINTS ARE FASTENED WITH HS67 PINS, TYPE 431 STAINLESS STEEL, HEAT TREATED TO 125,000 PSI MINIMUM SHEAR. THE HS60M COLLARS ARE R MONEL.

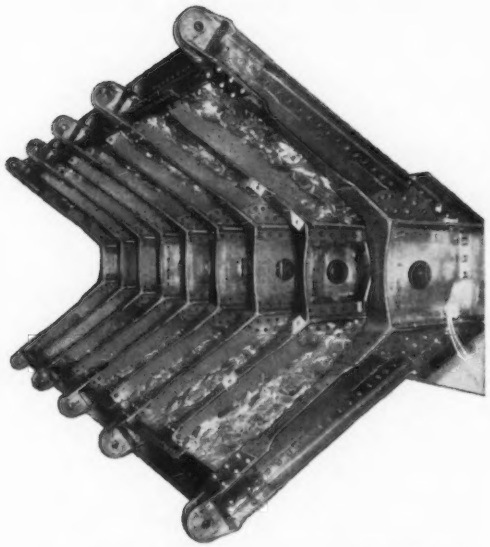


WING SPARS, FRONT AND REAR, HAVE SPAR CAPS ATTACHED TO WEB SECTIONS WITH HS92 PINS, A286 ALLOY, HEAT TREATED TO 95,000 PSI MINIMUM SHEAR HS60M COLLARS ARE USED.

OTHER FASTENERS MANUFACTURED AT HI-SHEAR INCLUDE HI-TORQUE BOLTS BLIND BOLTS BLIND NUTS AND HI-LOK FASTENERS

* designed and manufactured by North American Aviation, Inc.

*X-15 .. A CHALLENGE FOR FASTENERS



WING ATTACH STRUCTURE IS ASSEMBLED WITH INTERFERENCE FIT HI-SHEAR RIVETS. THE HS128 PINS ARE 17-4PH STAINLESS STEEL, HEAT TREATED TO 120,000 PSI MINIMUM SHEAR. THE HS91 AND HS92 PINS ARE A-286 ALLOY, HEAT TREATED TO 95,000 PSI MINIMUM SHEAR. BOTH PINS USE HS60M R MONEL COLLARS.

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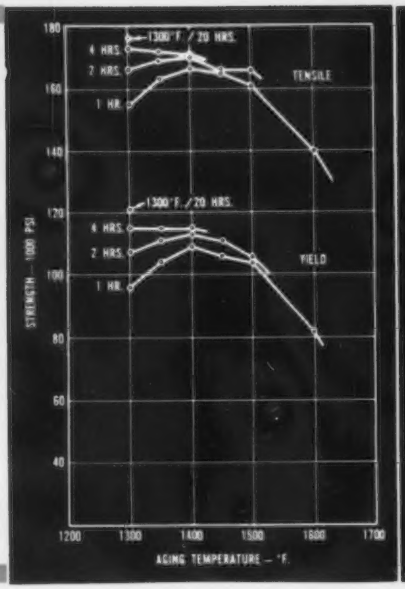
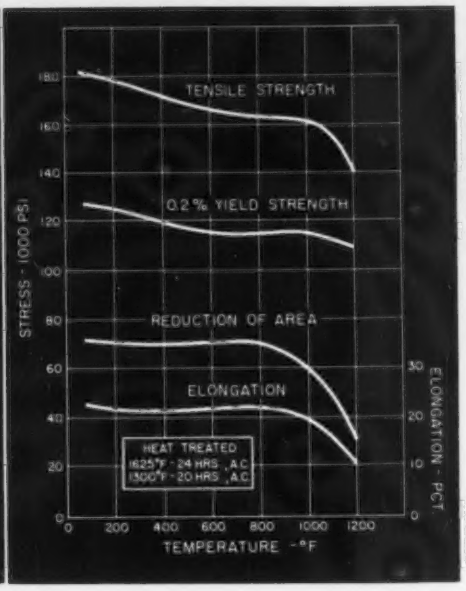
Fig. 1. Room-temperature properties of stress-equalized and aged Inconel X are given.

Fig. 2. The effects of time and temperature are shown on the tensile and yield strengths of annealed Inconel X sheet.





X-15—the material

proven high-temperature qualities and fabrication techniques influential in selection of Inconel X

by George C. Satris
The International Nickel Co., Inc.

Although Inconel X gained its public fame recently as the space-age superalloy used in the X-15, it was actually developed by the International Nickel Co. during World War II for use in jet engines. Since that time Inconel X has been a standard material for gas turbine rotating and structural components. Having been produced in most forms commercially for a number of years, considerable information already existed on its performance under various conditions, and the methods for fabricating it. This background had considerable influence on its selection for use in the first, manned space-research aircraft.

North American developed additional technology on the working, forming, and heat treating.

Precipitation Hardening

Inconel X (nickel-chromium-iron-aluminum-titanium-columbium alloy) was developed to have high stress-rupture strength, and low creep rates under high stresses up to 1500°F; resistance to chemical corrosion and oxidation are other attributes.

The high strength is the result of precipitation hardening. This gives one great advantage over the common method of hardening austenitic alloys, i.e., by cold work or so-called "hot-cold work." This advantage lies in the greater uniformity of properties from surface to center. Cold work tends to be more effective at the surface.

However, for service below 1100°F higher strength can be obtained in Inconel X by combining some cold work with heat treatment, since the effects are additive. Provided the end-use will be in this lower temperature range, material may be hardened by aging directly after hot or cold work or with an intermediate stress-equalizing treatment.

Heat Treatment

For service below 1100°F, the following

two-step heat treatment is frequently used:

1625°F for 24 hr, air cool (stress equalizing)

1300°F for 20 hr, air cool (aging)

This is specified in AMS 5667, which covers bars, forgings, and forging stock for applications such as bolts and turbine rotors, requiring high strength at temperatures up to 1100°F.

Equalized and Aged—1625°F/24 hr, air cooled; 1300°F/20 hr and air cooled.

Room-temperature Tensile Properties

Nominal Diam or Section Thickness, (in.)	Tensile Strength (min, psi,)	0.2% Yield Strength (min, psi)	Elong. (% in 4D min,)	Reduction of Area (min, %)
Under 4.0	165,000	105,000	20	25
4.0 and over	165,000	100,000	15	17

Fig. 1, gives high-temperature tensile-properties, stress-rupture, and creep-strength data on Inconel X in this condition of heat treatment.

Inconel X has greater machinability in the as-equalized condition than in either the as-forged or the equalized-and-aged condition. It contracts slightly during age hardening (about 0.03 per cent linearly) hence enough stock should be left on the piece to permit a final clean up after age hardening.

For maximum creep, relaxation and rupture strength at temperatures above about 1100°F, Inconel X is given the following three-step heat-treatment.

2100°F for 2 to 4 hr, air cool (solution treatment)

1550°F for 24 hr, air cool (high-temperature aging).

1330°F for 20 hr, air cool (low-temperature aging).

Again this heat-treatment is, in the case of forging, applied after the last operation.

AMS specification 5668 calls for this heat-treatment and also includes the following rupture-strength requirements: 1350°F and 45,000 psi—100-hr life, min. At 100 hr the load is increased to 70,000 psi and the test continued until the specimen fractures. The elongation after fracture, measured at room temperature, is required to be 5 per cent, min, in 4D.

The ability of Inconel X to retain its strength and ductility at extremes of sub-zero and high temperatures is illustrated by results of tests on cold-rolled, annealed sheet, aged 16 hr at 1300°F.

The tensile and yield strengths of the alloys are higher at sub-zero temperatures than at room temperatures, yet, there is no significant loss of ductility.

Test Temp. F	0.2% Y.S. psi	T.S. psi	% El. in 2-in.
—320	139,700	213,000	18.5
R.T.	125,700	181,300	22.5
1000°	100,500	144,800	22.0

Measurements of resistance to impact have been made on Inconel X over the temperature range —320°F to 1600°F in both the fully-heat-treated and the hot-rolled-and-aged conditions.

In the following table, the individual Standard Charpy V-notch test results have been averaged to give impact-strength values.

Temp °F	2100°F/2 hr 1550°F/24 hr 1300°F/20 hr ft lb	Hot Rolled plus 1300°F/20 hr ft lb
—320	33	34
—109	36	37
75	37	38
400	42	44
800	50	46
1000	49	49
1200	45	43
1350	49	49
1500	67	53
1600	113	82

Sheet and Strip

Inconel X sheet and strip used by North American were supplied in the cold-rolled, mill-annealed temper. Parts requiring high strength up to 1500°F, and oxidation resistance up to 1800°F may be formed and then heat-treated to improve strength at elevated temperatures.

AMS specification 5542 for Inconel X sheet and strip includes the following requirements.

Mill-annealed and aged 1300° F/20 hr, air cooled

Form	Thickness (in.)	0.2% Yield Strength (psi max)	Tensile Strength (psi min)	Elongation % in 2 in. min
Sheet	0.025 and over	100,000	155,000	20
Strip	Under 0.010		150,000	
Strip	0.010 to 0.025		155,000	15

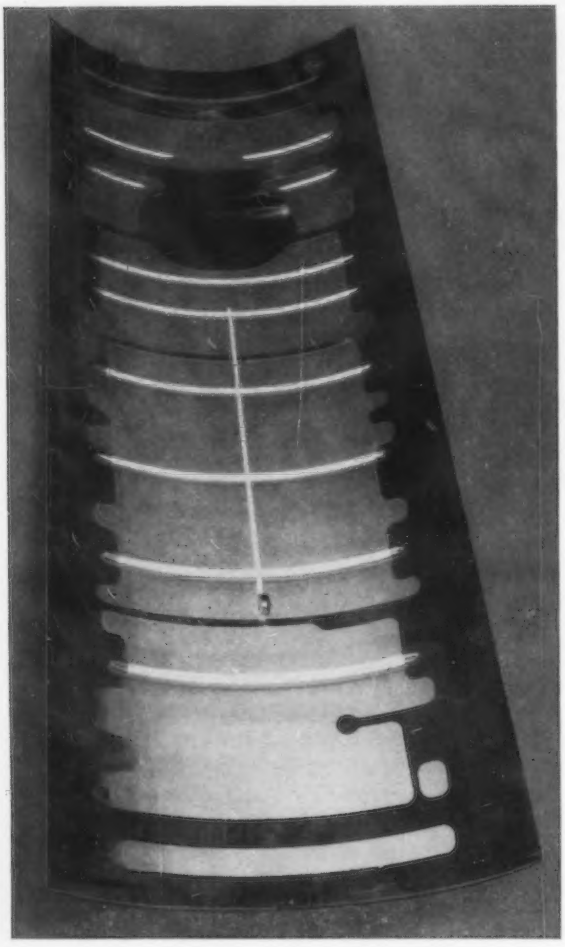
Although an aging treatment of 1300°F for 20 hr is required by specification, there may be occasions when a shorter aging-time will be useful, since most of the hardening occurs within the first few hours. For instance, North American applied an aging treatment of 10 hr at 1300°F. Fig. 2 shows the effects of time and tem-

perature on the tensile and yield strengths of annealed Inconel X sheet.

When fabricating parts from thin sheet or strip Inconel X at NAA the alloy required some annealing or stress relieving during and after working. Because of the soft condition of the material after annealing, warpage was easily removed.

During stress relieving warpage of some fabricated or welded components for the X-15 was minimized by the use of fixtures and controlled cooling. Most pieces, even the large weldments, did not require subsequent straightening, despite rapid heating during stress relieving of fabricated parts. Little warpage was expected or took place during the 1300°F aging treatment.

Inconel X side panel for lox tank is chem-milled extensively and beaded.



Welding

Inconel X sheet can be easily joined by metal arc, tungsten inert-gas arc, and inert-gas consumable-electrode methods, as well as by resistance welding. Welding is normally done with the material in the annealed condition. If the parts are formed by cold working they should be annealed prior to welding, by charging directly into a furnace at 1800°F holding for 10 to 15 min, followed by air-cooling.

Resistance and fusion welding were performed on X-15 parts using standard equipment and processes. Spot and seam resistance-welding and MIG and TIG fusion welding were used for various parts. On the basis of tests, North American decided that it was undesirable to weld Inconel X when it was harder than 25 Rockwell "C." If the material to be welded tested higher than 25 Rockwell "C" it was annealed before welding. This was to insure sufficient ductility during welding, to relieve occurring stresses.

A standard practice when welding Inconel X parts, some portions of which can only be joined after age hardening, is to "safe end" the parts with Inconel.

Inconel (different from Inconel X, in that it does not respond to age hardening) made it possible for North American to use the "safe end" technique in several situations, especially in close-out welding of tanks. The Inconel X components could then be given the full age-hardening treatment, since the only welding done was performed on the safe ends.

Chem-Milling

Chem-milling, developed by North American, was used for the forming of pockets on contoured and shaped sheet-metal parts. Reports from NAA on tensile tests, 1000°F stress-rupture tests, and 1000°F fatigue tests showed that chem-milling does not affect properties of the alloy. Metal removal was about 0.001 in./min, thickness tolerance ±0.002 in. over original thickness tolerance, and the surface roughness was about 100 rms.

North American reported that standard forming procedures and methods were used to form Inconel X; its formability was found excellent and compared closely to that of annealed 301 stainless steel. No difference in formability between the longitudinal and transverse direction was noted.

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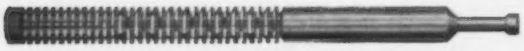

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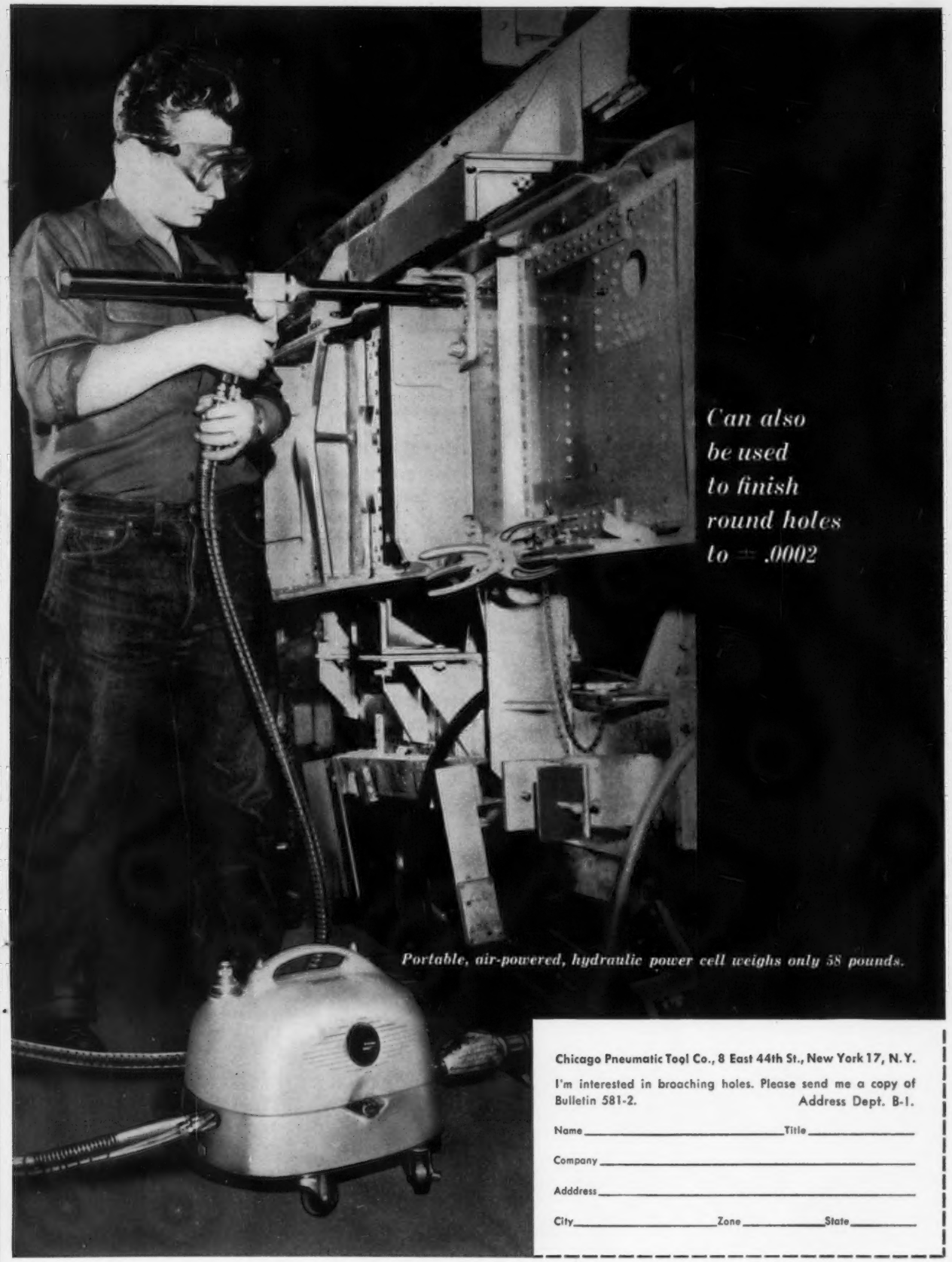

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X-15—the engine

single-malfunction safety dominant throughout design; self monitoring feature relieves pilot of burdens; start-stop-restart capability a first

by John P. Kushnerick

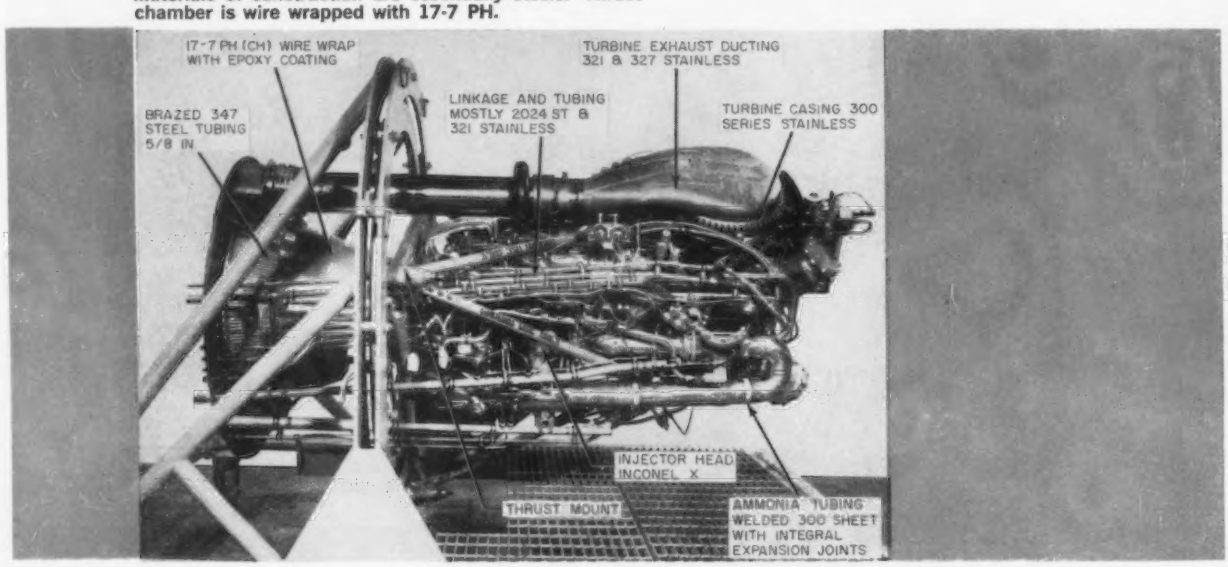
With the design and testing of X-15's powerplant, Reaction Motors has tamed a mighty giant—the large liquid rocket engine. No longer is this potent power source an uncontrolled brute once it is unleashed. For, in making a 50,000 lb thrust engine safe to carry man out of the atmosphere, and in giving man direct throttling and start-stop-restart capabilities over the engine. Reaction has created "the first gentleman of the rockets." The XLR-99.

Starting with engineering work done on the rocket engine for Super Viking, a missile which never materialized, RM set out on the X-15 project. The object was to produce a powerplant capable of powering the 31,500-lb X-15 research vehicle 100 mi beyond earth, survive reentry, and be reusable. All this while keeping pilot safety paramount. Start-stop-restart capabilities in the air, as well as wide-range throttlability were added, to put engineering problems way out of any existing "ballpark."

Design Goal—Single Malfunction Safety

The visible, working result of RM's effort

X-15's powerplant delivers over 50,000 lb thrust at sea level. Materials of construction are essentially steels. Thrust chamber is wire wrapped with 17-7 PH.


17-7 PH (CH) WIRE WRAP WITH EPOXY COATING
BRAZED 347 STEEL TUBING 5/8 IN
LINKAGE AND TUBING MOSTLY 2024 ST & 321 STAINLESS
TURBINE EXHAUST DUCTING 321 & 327 STAINLESS
TURBINE CASING 300 SERIES STAINLESS
INJECTOR HEAD INCONEL X
THRUST MOUNT
AMMONIA TUBING WELDED 300 SHEET WITH INTEGRAL EXPANSION JOINTS

POWERPLANT SPECIFICATIONS

Designator:	XLR-99-RM-1
Manufacturer:	Reaction Motors Div. Thiokol Chem. Corp.
Type:	Regeneratively cooled, liquid
Designed Use:	X-15 research vehicle
Dimensions:	6 ft long, 3 ft wide
Thrust:	50,000 lb (plus)
Thrust/Weight:	60-70 to 1
Fuel:	liquid ammonia
Oxidizer:	liquid oxygen
Mixing Ratio:	1.25 oxidizer to 1 fuel
Specific Impulse:	250 to 260 sec (est)
Combustion Temp:	4950° F (theoretical)
Chamber Pressure:	600 psi
Fuel Flow:	10,000 lb/min (plus)
Burning Time:	limited by X-15 fuel, 19,000 lb max
Ignition:	electrical
Throttlability:	complete, in throttle range
Restart:	air restart possible
Overhaul Life:	"quite a few minutes" (Reaction)

is a LOX-NH_3 consuming, single-chamber engine, designed completely around "single malfunction safety." This means that the requirements of MIL-E-5149 and ANA Bulletin 428 have been, or will be, met. The engine is self monitoring to the extent that it safeties itself on the malfunction of any single component which could conceivably damage the aircraft. One component cannot cause another to fail, hence, chain reaction failures are prevented.

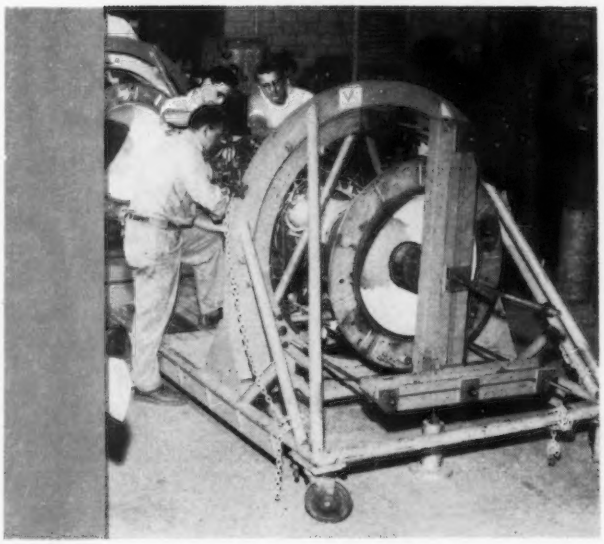
Achieving piloted safety is not to be confused with achieving reliability. An engine with high reliability could fail catastrophically if it did not have single-malfunction, piloted-safety provisions.

One Pint Critical

The biggest problem in designing to piloted safety, was to prevent the accumulation of more than 1 pint of propellant in the combustion chamber. Sudden deflagration of this amount of fuel and oxidizer could cause destruction of powerplant and aircraft. Considering that propellant flow is in excess of 10,000 lb min, this minute quantity of 0.4 lb of NH_3 and 0.5 lb of LOX could be accumulated in approximately 5 milliseconds.

With such a critical time factor, sensing mechanisms could not be relied upon to detect this propellant accumulation in the thrust chamber. The approach had to be by way of preventing the accumulation. This has been achieved by checking flow and pressure rates at virtually every juncture in the propellant system. No large computers are used; rather, intelligent use of valve redundancy and series-parallel circuiting achieve the result. A thrust chamber geometry which does not exist in any missile engine in this country also plays a major part in safety. RM does not discuss details, except to say that the engine remains "cool" at low power outputs where there is a limited amount of fuel being pumped for regenerative cooling.

Partially assembled engines are shown in special 360 deg rotatable fixtures at Reaction Motors. First XLR-99 should be delivered in late summer or early fall.



Design Briefs

There are several design features about this powerplant that are peculiar to it among single-chamber, liquid-propelled engines.

IDLE CAPABILITY allows the pilot to complete about 85 per cent of the starting sequence while the plane is still attached to B-52 mother ship. This includes running of the turbopumps and initiating part of the ignition cycle.

THROTTLE CAPABILITY gives pilot the option of continuously selecting full or partial power. XLR-99 is said to be "completely throttlable" within a certain range. The extent of this "range" is not divulged, but is said to be considerable.

DUMP SYSTEM allows pilot to use the pressurizing helium in the propellant tanks to jettison the complete fuel load in a matter of seconds. Tanks will also be purged before all landings.

STOP-RESTART can be achieved in flight. Engines like XLR-11 which powered the X-1 vehicle contained several thrust chambers. Individual chambers could be shut down and restarted as long as at least one chamber remained in operation. Restart, coupled with throttling will take some demands off guidance systems in future vehicles.

continued on next page

ROKIDE "Z"

Zirconia Coating for X-15 Thrust Chamber

Thickness: recommended range	0.005 to 0.050 in.
Composition	98% lime stabilized ZrO_2
Crystal form	cubic ZrO_2
Bulk density	5.2 gms per cc.
Total porosity	8 to 12% (7% open)
Permeability	slight
Abrasion resistance	high, Knoop hardness 1000
Adherence to base materials	good
Surface finish	a few hundred microinches.
Strength	good
Chemical resistance	good
Thermal conductivity	8 BTU / hr / sq ft. in. / °F at 1000° to 2000° F.
Total emissivity coefficient	0.3 to 0.4
Thermal expansivity	5.4 x 10^{-6}/°F from 70° to 2250° F.
Thermal shock resistance	very good
Electrical conductivity	nonconductor at RT; conductivity increases rapidly above 1200° C.
Heat resistance	very high; 4500° F required to melt.
Color	light tan

SELF-MONITORING feature allows engine to safety itself in event of a single malfunction. This provides unmatched piloted-safety, air-restarts.

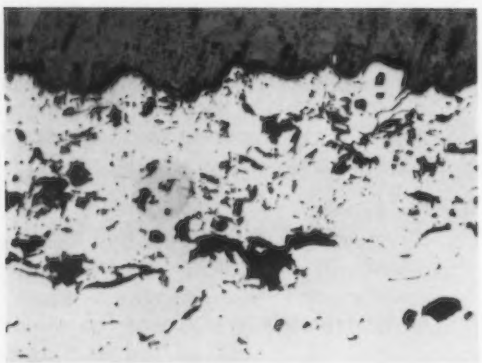
CONVERTABILITY to other fuels and other vehicles is seen possible without extensive rework. Use of hypergolics would eliminate or simplify the ignition system. Storable propellants will be used, as will any number of cryogenic combinations.

REUSEABLE feature means that most components will withstand reentry and max-speed flights. Overhaul life of the engine is "quite a few minutes."

COMBUSTION CHAMBER is of unique geometry. It is conventional only in that it is regeneratively cooled by passing liquid ammonia through "stainless spaghetti" walls.

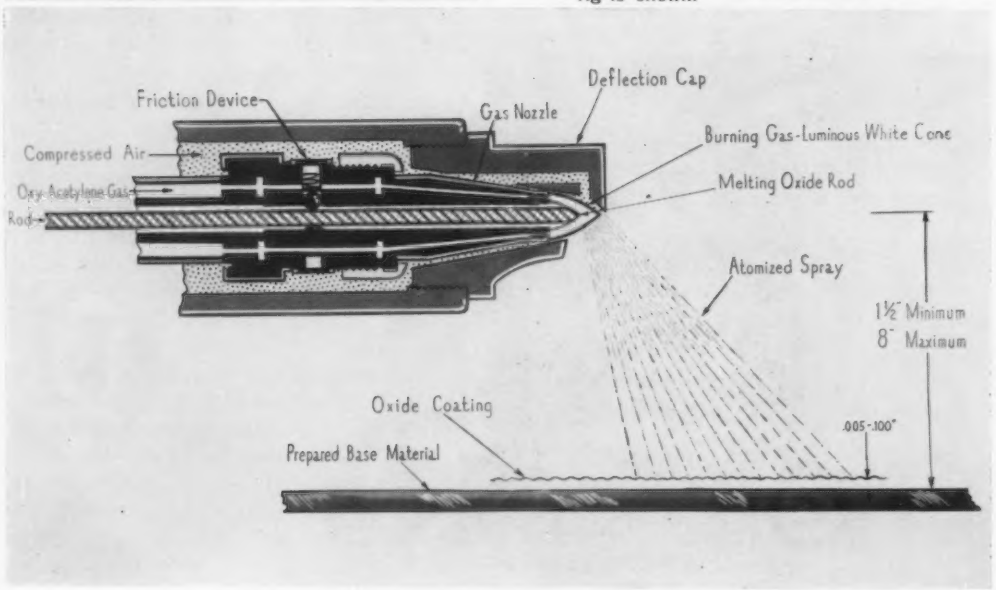
Testing

RM testing on this engine is more extensive than on any other engine of its type. Proving out the self monitoring features over a wide environmental range has brought this on.



Photomicrograph of Rokide Z on stainless steel at 100 magnifications. Thin layer of nickel is used in sample for better adherence. Norton recommends this, RM developed own surface preparation technique.

Interior of thrust chamber is coated with Rokide Z, a zirconium oxide ceramic. The flame spraying process is used. Hot zirconia rod is fed into hot (2000-5000° F) oxyacetylene flame, and compressed air is used to atomize melted rod. Typical rig is shown.



Reentry tests are considered the most severe. It was felt that if these could be satisfied, other requirements would take care of themselves, for the most part. Engine compartment temperatures vary with mission. The reentry mission will induce highest engine compartment temperatures. In simulating reentry, the engine is put in a hot box, soaked, and then fired up.

Engine has also been subjected to sustained low temperature environments before firing.

Firing stands allow simulation of fixed pitch and roll attitudes while the engine is running. The effects of fuel sloshing, however, cannot be simulated.

The advantages of sled tests to simulate G forces have long been under discussion. None are planned at present.

Design Particulars—Materials

From a materials standpoint four major accomplishments brought XLR-99 to reality:

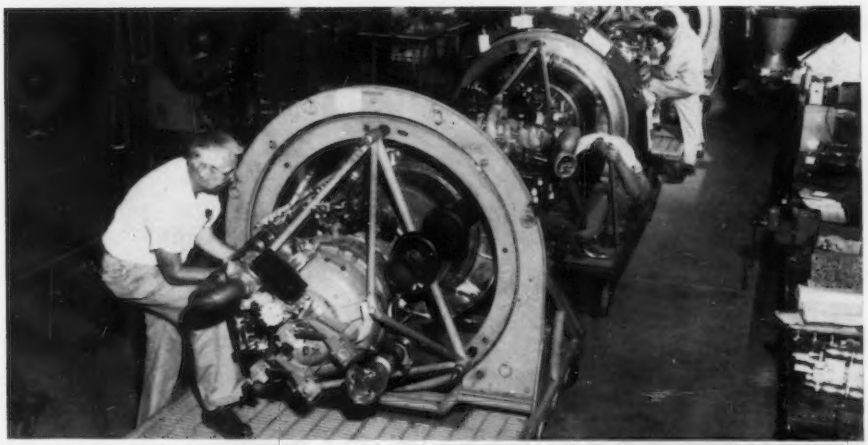
- Finding the material and developing a producible design for the main turbine. Utica Drop Forge & Tool, Ladish Co., and RM share credit here.

- Developing welding techniques compatible with combustion chamber design. This includes producing brazements that could have components welded to them. RM worked with many people in this area, but feels the techniques which evolved are basically extensions of their own thinking.

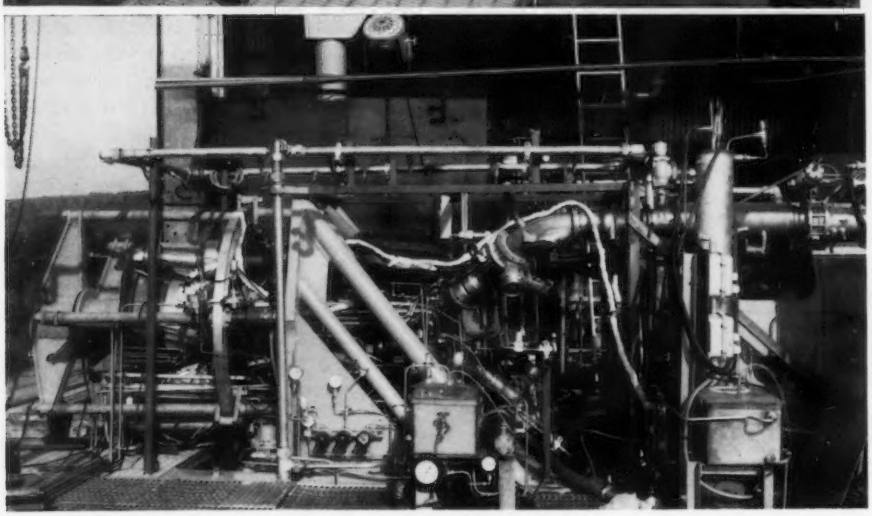
- Providing ceramic protection on the internal surface of the combustion chamber. Norton Co.'s Rokide Z is used, but RM developed surface preparation techniques.

Thrust Chamber

The thrust chamber is regeneratively cooled by liquid ammonia. Hundreds of stainless steel tubes are formed to the chamber geometry, and brazed together. A complicated scalloping allows the liquid ammonia to go aft in one



Engine without plumbing installed gives some indication of injector - head configuration. Inconel X plays big part in engine as well as airframe.



XLR-99 is probably most tested engine of its type. Engine is shown here on firing stand. Pitch and roll can be simulated on stand. Engine has been fired after simulated reentry test (hot box soak).

the engine . . . continued

tube and then forward through a pre-selected tube in the completed chamber. Fabricating the chamber involves:

- SHAPING THE TUBES. Tubes are purchased round in 347 stainless stock. O. D. is 5/8 in. and wall thickness is 0.035 in. Before brazing, the tubes are slightly flattened. RM feels swaged tubing, or the "channel type" thrust chamber offers greater potential than the round tube, but cost and state of the art has made them settle on present methods.

- FORMING THE TUBE BUNDLES to chamber geometry. A mandrel used.

- BRAZING THE BUNDLE. Coast Metal 62 or 63 brazing alloy is used. This is a magnesium alloy containing 14 Ni, 14 Cr, and less than 1 per cent Bo. Grain penetration is slight. Wetting and ductility in the final braze are good. Bulk of brazing is done in a high temperature hydrogen brazing furnace.

- WELDING OF MANIFOLD AND ACCESSORIES. Heliarc welding techniques have been developed for welding of Inconel X directly onto the brazed areas.

- HEAT TREATING is performed to induce maximum strength in Inconel X.

- FLAME SPRAY of chamber interior with ceramic. Norton's Rokide Z is used to a thickness of 0.020 to 0.040 in. to protect the 347 stainless from 5000°F chamber temperatures. The flame spraying principle is a great deal like that of the household atomizer. The process however is carried out at 2000° to 5000°F.

- WIRE WRAPPING of the chamber with 17-PH(CH) and coating the wire with an epoxy binder completes the processing of this component.

Turbine And Pumps

The turbine which drives the propellant pumps is powered by hydrogen peroxide. The turbine disc is forged from Udimet 500, and blades are investment cast of Udimet 500 by Austenal Inc., and Misco Precision Casting Co. Shaft is 17-7PH stainless, and the casing is 300 series stainless. Ducting which vents exhaust overboard is 320 and 325 welded stainless sheet.

The propellant pumps themselves are housed by a cast ZH65-T6 magnesium case. Shaft bearings are of 52100 steel, roller variety. Some Al_2O_3 sliding bearings are used.

Sealing Materials

Most of the liquids handled in XLR-99 are highly reactive. Mixing oxidizer with fuel, or oxidizer with organic lubricants could be catastrophic. Effective sealing has been achieved with the following materials:

- H_2O_2 system—Dow LS 53, Kel F 5500, Linear XWT22 and Teflon. The latter is used principally as squeeze gaskets.

- LOX system—Buna and natural rubber 7247, Flexitallic asbestos filled Inconel sheating, and Precision 711.

- Hydraulic system—essentially conventional sealing materials.

- Lubrication system—Fluorolube and Halocarbon fluids are used. Seals are therefore of the halocarbon class.

Engine is attached to the X-15 airframe through a 4130 forging. North American Aviation shear washer arrangement is used in the three point attachment.

Make or Buy

About 55 to 60 per cent of the components in X-15's engine are sub-contracted by RM. However, practically all of these are engineered at RM. Off the shelf components have been reengineered in many cases to satisfy this powerplant's special missions.

At present, the program calls for outfitting three aircraft and producing sufficient spares to see X-15 through its complete flight test program. This should extend over several years. The first XLR-99 will be delivered in late summer or early fall. First powered flight with this engine should take place before the end of the year.

In the interim, X-15 will be powered by two multi-chambered XLR-11's. XLR-99 should give X-15 hypersonic speeds (greater than Mach 5), and propel it over 100 mi, but less than 200 mi, beyond Earth when launched from a B-52. These limits could easily be exceeded by B-70 or Navaho-booster launch.

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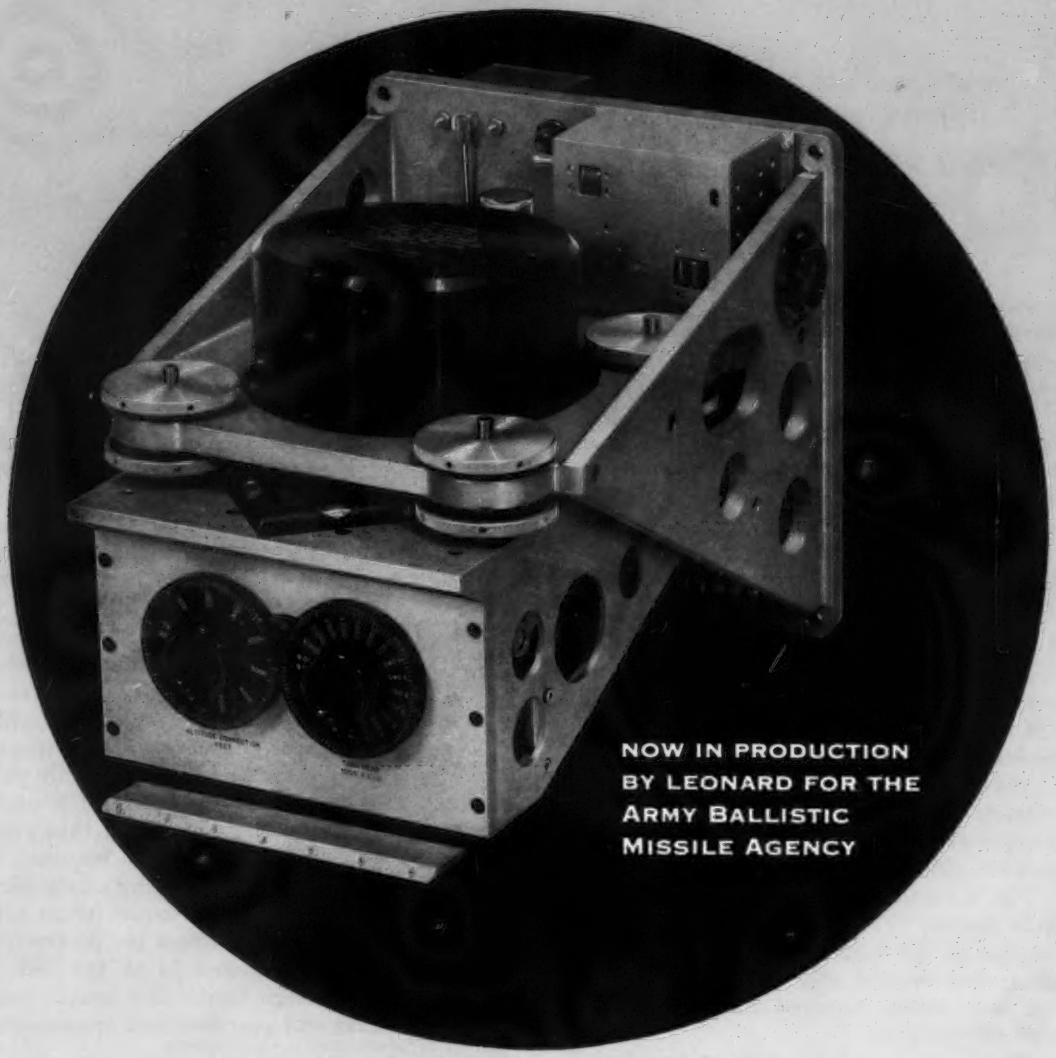

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Circle 10 on Inquiry Card, page 89

X-15–flight instruments

pure inertial system gives attitude, altitude, and velocity data; may pave way for space navigation

A pure-inertial system is used to record, and display attitude, velocity, and altitude data in X-15. Four types of airborne instrumentation were considered:* pressure, radar or radio, simple gyroscope, and inertial. Each had limitations. The only limiting factor in an inertial system was "flight duration." Since inertial components equal to the task of X-15's short flight duration were attainable, this system was selected.

Functional Description

The inertial flight-data system can be divided into two groups:

The first group, carried in the B-52, mother ship, is used to supply the proper initial conditions to the computer, and thus align and stabilize the instrument platform prior to launch.

The second group is carried in the X-15 and consists basically of the stabilizer, computer and indicators. This equipment supplies all of the required data after the X-15 is launched.

Fig. 1 contains a functional schematic of the X-15 system. The data insertion equipment was located in the B-52 carrier aircraft to save overall system weight and to relieve the X-15 pilot of any duties required in the prelaunch phase of the mission.

The inertial part consists of two fundamental components: the stabilizer, which contains the sensory elements, and a computer. The computer processes data from the sensing elements to get usable velocity, position and altitude data. Both components are mounted on a stabilized platform.

A simplified diagram of the system after launch is shown in Fig. 2.

* *Airborne instrumentation is supplemented by telemetry and radar tracking.* *See "High Range" page 42.*

Gimbal System

Four distinct axes of rotation are present in the stabilizer. The sequence of rotational freedom from the case inwards are roll, pitch, inner roll, and azimuth. The pitch, inner roll, and azimuth axes are maintained mutually perpendicular. The outer roll axis is gimballed with respect to the foreaft aircraft axis and operated in conjunction with the inner role axis to produce an angular displacement proportional to aircraft roll attitude. The redundant roll axis allows the aircraft unlimited maneuvering without the possibility of gimbal lock or loss of verticality.

Basically, the gimbal design consists of direct drive torques, and single speed readout synchros mounted at each end of slightly elliptically shaped gimbals. The servo amplifiers for each axis are transistorized and mount directly on the gimbal being driven; the gimbal itself is used as a heat sink for the power transistors, thus greatly reducing the number of slip rings required. The design approach eliminates gearing on the gimbal axes. This minimizes disturbance forces acting on the platform and enhances its performance. The gimbal servo response is of the order of forty cps since design limitations usually caused by shaft flexure and gear backlash are essentially eliminated.

Slip rings are provided on the outer roll and azimuth axes.

Stable Platform Assembly

The sensing elements mounted on the stable platform are:

- Three linear accelerometers
- Three integrating gyros
- Ten transistorized amplifiers required to operate the gyros, accelerometers and gimbal servos.

continued on page 28

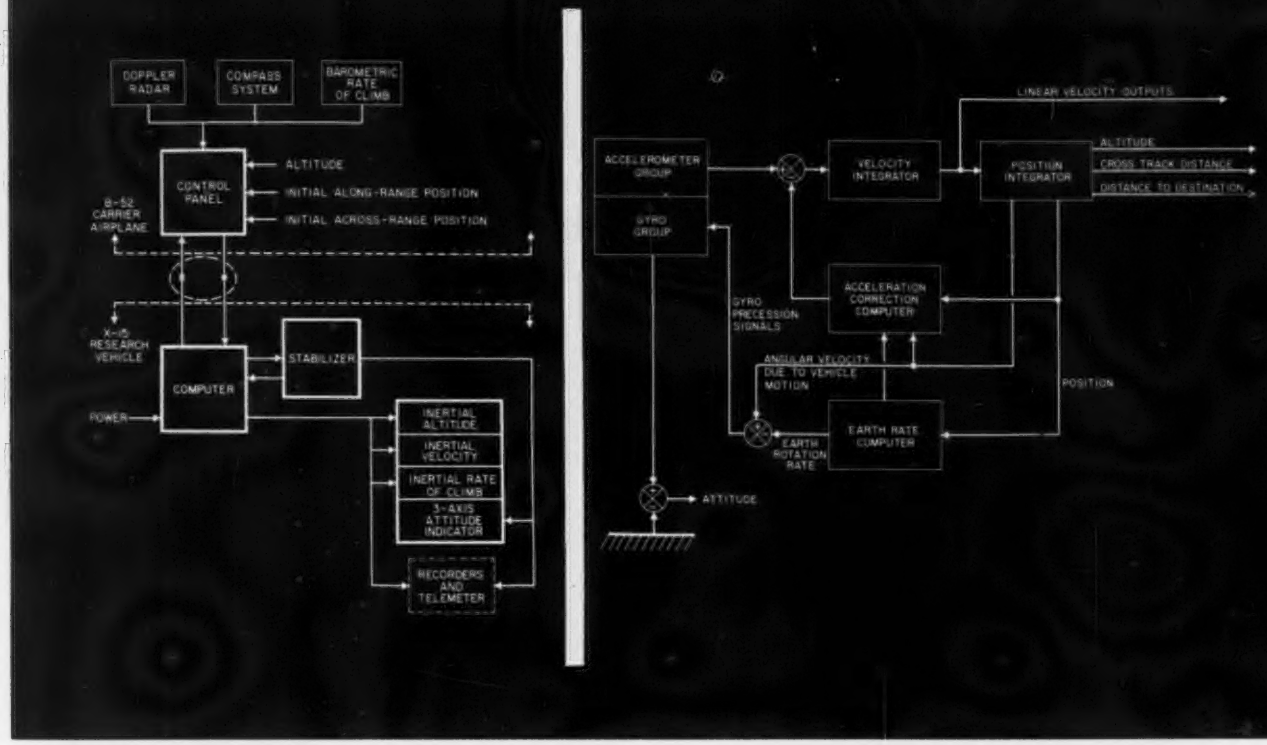

Fig. 1. Block schematic of flight data system shows what parts are retained in B-52 Mothership, and which stay with X-15. B-52 components orient complete system before drop.

Fig. 2. After launch these components remain with X-15. Weight saving was achieved by having data insertion equipment stay with Mothership.

CHARACTERISTICS OF X-15 INERTIAL SYSTEM

Characteristic	Value	Remarks
Stabilizer Weight	55 lb	Mg platform, gimbals and housing.
Amplifier Weight	—	Integral to Stabilizer — transistorized.
Heat Exchanger Weight	—	Integral to Stabilizer.
Shock Mount Weight	From 0 to 27 lb.	Dependent upon vibration environment and desired accuracy of spatial attitude readout.
Stabilizer Volume	1.2 ft³	Cylinder 18 in. long by 12 in. diam.
Power Required	240 watts	3ϕ 115 Delta or 208 wye 400 cps.
Internal Operating Temperature	95° F	Thermostatically controlled by metering of cooling gas. Control integral to stabilizer.
Coolant Required	3 lb/min typical	Air-gas (Nitrogen, or freon etc.) mixture at 0° C and 9 in. H_2O.
Operating Life	1000 hr	Design requirement.
Gimballing	All Attitude	Yaw, inner roll, pitch, outer roll, case from inside out.
Maximum A/C attitude		
Yaw	Unlimited	
Pitch	Unlimited	
Roll	Unlimited	
Maximum A/C rate		
Yaw	4000 deg/sec	30 deg / sec in loop maneuver through vertical.
Pitch	2500 deg/sec	
Roll	2500 deg/sec	
Maximum A/C acceleration		
Yaw	1800 deg/sec²	
Pitch	1500 deg/sec²	
Roll	1500 deg/sec²	
Warmup time	15 min	From −65° F ambient.
Vertical Accuracy	2 min of arc max.	Under dynamic inputs.
Gyro		
Random Drift	0.05 deg/hr.	Floated rate integrating.
Mass Unbalance	1 deg/hr./g	max
Anisoelastic	0.02 deg/hr/g²	max
Reaction Torque	1 deg/hr.	max
Fixed Drift	0.1 deg/hr.	max
Angular Momentum	1 x 10^5 gm cm²/sec.	
Weight	0.48 lb.	
Size	1.75″ D 2.75″ L	
Torquers	± .25 per cent	
Temperature	187° F	Controlled to ± .5° F by proportional control amplifier.
Accelerometers		Test mass, d-c force coil restoration with servo damping.
Linearity	±0.0003 g or .1 per cent of acceleration whichever is greater.	Accuracy includes null shifts, scale factor variation and mounting pad misalignment, all over a six month period.
Resolutions	5 x 10^{-6} g	
Range	± 10 g	
Weight	1.5 lb.	Includes pre-amp.
Size	¾ x 2⅞ x 1¾	
Gimbal Synchros	2 min 1σ	Direct drive synchro.
Gimbal Drive	Servo Torque	
Azimuth	0.35 ft. lb	Direct Drive.
Inner Roll	0.85 ft. lb	D-C torquers
Pitch	0.85 ft. lb	Powered by Transistor
Outer Roll	1.8 ft. lb	Gimbal servo band- s. width 50 cps.

flight instruments . . . continued

	Pressure	Doppler or Radio	"Simple" Gyroscopic	Inertial
Measurements required:				
Velocities	X	X		X
Altitude	X	X		X
Attitude Angles			X	X
Limiting Factors:				
Accelerations			X	
Velocity Range	X			
Altitude Range	X			
Attitude Range		X	X	
Flight Range			X	
Flight Duration			X	X*
Power Required		X		
Cooling Required		X		

* For extended duration.

Closeup shows stable platform mounted in inner roll gimbal. Ten subminiature amplifiers, 3 integrating gyros, and 3 accelerometers are core of platform. Complete platform weighs 55 lb.

Heart of X-15 inertial attitude and navigational system is the stable platform shown being checked with oscillograph at Sperry Gyroscope Co.

Three 10^{+5} gm-cm^2/sec floated rate-integrating gyros are used with associated heater amplifiers to maintain the operating temperature of the gyro within narrow limits. Newly-developed Sperry linear accelerometer consists of a test mass, a capacitive sensing element and a force balance servo amplifier. The output of the accelerometer is a d-c current proportional to acceleration.

Housing and Cover Assembly

The stabilizer housing contains all power supplies and accessory equipment necessary to operate the stabilizer. The case configuration serves as a heat exchanger between external cooling air and the internally circulated air. Design consists of two concentric shells with a corrugated surface sandwiched between. The external-air flows on one side of the corrugated surface and the outer shell, while the internal air is circulated through the other side of the corrugated surface and the stabilizer. The corrugations considerably increase the area of heat conduction from the platform air to the external cooling air.

Computer

The computer translates attitude, velocity, and position data to a usable form. The following functions are performed:

- Doppler Inertial Mixing
- Gyro Drift Storage
- Acceleration to Velocity Integration
- Velocity to Position Integration
- Earth Rate Computations
- Acceleration Corrections due to Kinematic Velocities

Unique features of the computer are its lightweight, high accuracy, and compatibility with the stabilizer sensing elements. These are achieved thru the use of d-c analog computing techniques which keep system noise and weight to a minimum.

The computer consists of repeated use of two basic computing blocks. One is a precision integrator that uses a Sperry made d-c tachogenerator as the fundamental accuracy determining element. These tachometers have been tested in quantity and all have accuracies better than 0.01 per cent. Integrators are packaged in two groups of three (velocity integrator group and position integrator group) with all electronic accessory equipment included in the subassembly group. This design approach simplifies maintenance and test of the system so that when the system is installed in the X-15, trouble shooting need only progress to the computer group level. The computer group can then be replaced and can be tested outside of the computer harness on the bench at a later time.

Similar packaging concepts are used with the second computing element, an integrator used to erect and align the platform.

The acceleration corrections and Earth rate computations are accomplished passively with resistor networks and potentiometers.

All supplies needed to power the computer are also packaged in this unit.

Control Panel

The computer is connected to the control panel in the B-52 through the umbilical connector (See Industry Notes). This panel provides controls and indications for:

- The system-mode selection
- Manual insertion of initial altitude and position data
- System performance monitoring prior to launch

It also contains the converters and couplers necessary to introduce the initial velocities and heading angle into the system for alignment purposes. It should be noted that the control panel operator in the B-52 has the responsibility of making the initial settings and mode selections, as well as that of monitoring the alignment process to assure proper system operation. X-15 pilot is relieved of these responsibilities. Another feature is that critical test points in the X-15 system are monitored enabling the operator to evaluate the performance and detect malfunctions of the X-15 inertial system while it is being carried by the B-52 aircraft.

Indicators

The X-15 Inertial System has four flight instruments which aid in the piloting of the aircraft. Three of these instruments have been specially designed for the X-15 aircraft while the fourth is a reengineered three-axis attitude indicator.

New, are the self contained altitude indicator, which operates on synchro data from the computer, the vertical velocity indicator, and a total velocity indicator. The vertical velocity indicator which will be used during high speed level runs of the aircraft is a simple meter movement type instrument. The total velocity indicator is a computing mechanism which receives the three components of the velocity from X-15 inertial system and derives and displays total vector velocity of the aircraft.

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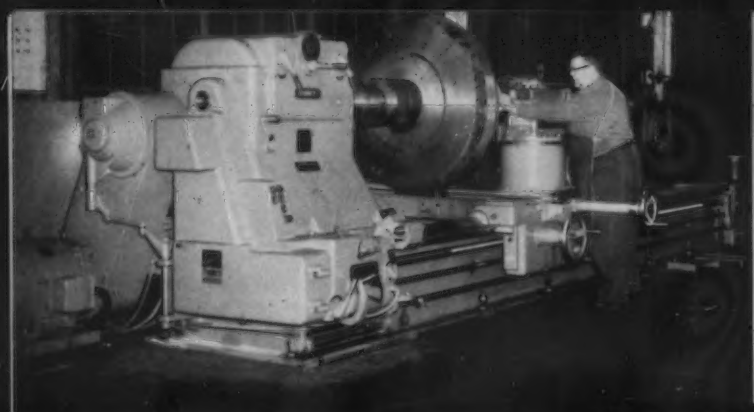
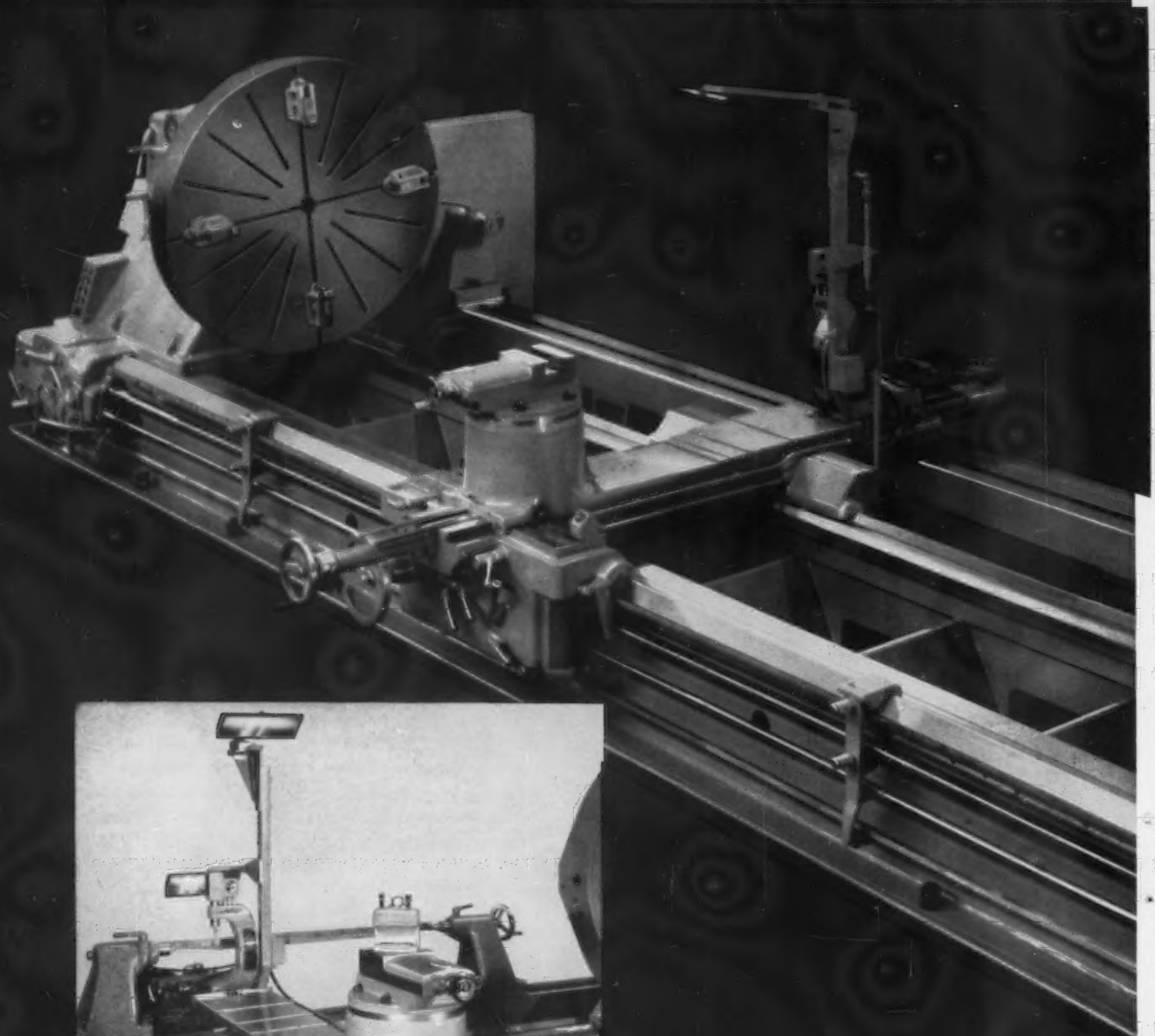
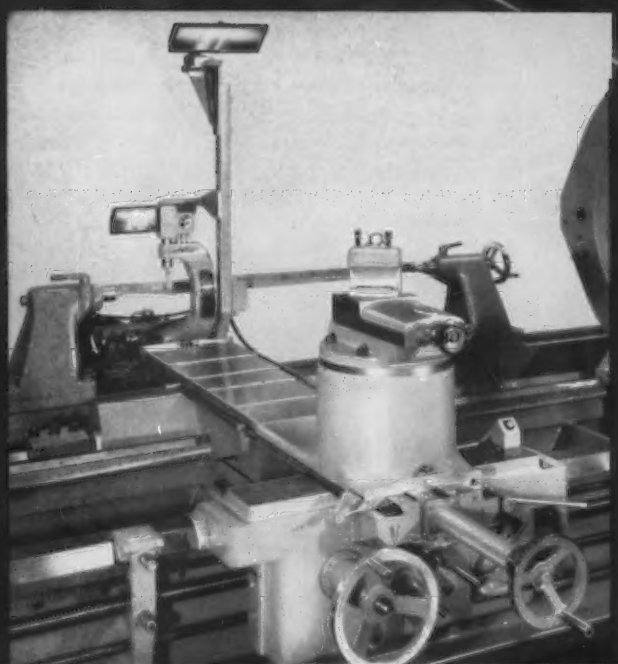


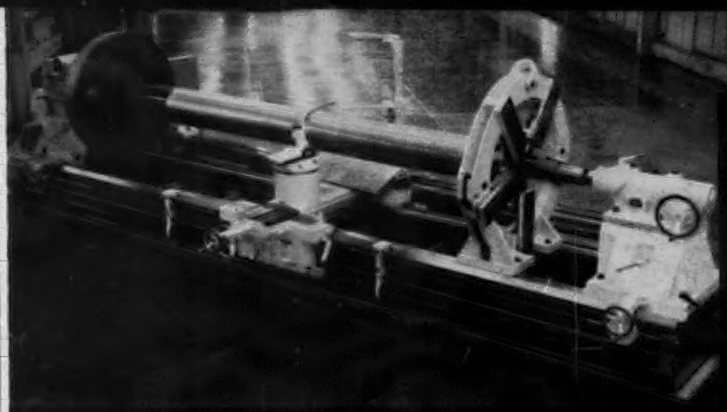
A large missile component being tracer-machined at a major West Coast missile plant on a Space-Master with 60″ swing and 21′ centers.

This Sidney Space-Master is contouring steel rolls up to 50″ diameter to close tolerances.





Close-up of the Sidney Fluid Tracer with periscope mirrors which permit watching the tracer while machining large work.



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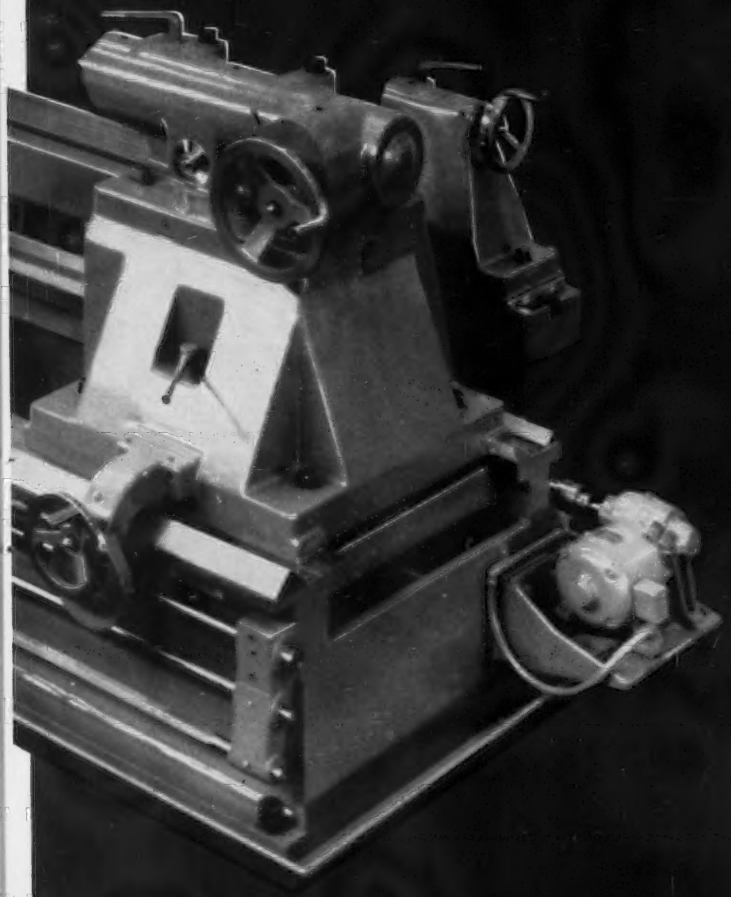

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Circle 11 on Inquiry Card, page 89

X-15–hydraulic seals

filled-Teflon used as extrusion barrier for rubber O-rings; Oronite fluid reaches 500°F at 3500 psi

In flight, the hydraulic systems of the X-15 will be subjected to temperatures of 500 deg F and pressures up to 3500 psi. Fluid for the systems is Oronite formula 8515.

Rubber rings used as buffers between the moving parts of the hydraulic systems deformed under the heat and pressure of environmental tests. In the deformed condition, the rings moved into the clearance space between the moving parts and were damaged physically and chemically.

A collar or ring was needed which would expand, filling the gap between the moving members and forcing the rubber ring to remain seated. Also, this anti-extrusion barrier had to resist heat and the corrosive effects of the hydraulic fluid.

The problem—find a material to do the job. Environmental tests showed TFE (tetrafluoroethylene resin) to be well suited for the control collar material. A filler in the Teflon improved its stability and made it more impervious.

Next problem — machine to close tolerances. Systems engineers specified that the OD, ID, and thickness had to be held to plus or minus 0.001 in.

This problem was turned over to Raybestos-Manhattan, Inc., Paramount, Calif. The firm developed special diamond-faced cutting tools to mill the filled TFE. Tube stock was used which had undergone extensive heat treatment for some weeks. The pre-stabilized stock was checked for required values of temperature resistance, dimensional stability, and chemical inertness. Cured stock was boiled in Oronite fluid for four hours at 650 deg F. Then the material was machined to sizes ranging from ⅛ in. diam to 8 in. diam.

Raybestos-Manhattan has delivered 25,000 of these rings for the X-15 program. Approximately 6000 have been used for tests. The balance provides 2500 in each of the three craft, 7500 for spare parts, and the remainder is stockpiled.

Rod seal of an X-15 hydraulic control actuator is fitted at a buffer point with a Teflon anti-extrusion ring or control collar. Inset shows close-up of the joint area.

✦

Circle 12 on Inquiry Card, page 89 ——→

LINDE's NEW PLASMARC TORCH SERVICE

Brings Industry Production Parts From Refractory Metals

No other method of fabricating refractory metals can match this. . . . The high melting points of tungsten, tantalum, and molybdenum are no longer a problem. For LINDE's new *PLASMARC* Torch, working in the temperature range between 15,000 and 30,000 degrees K., can coat parts or form shapes of virtually any size or complexity. It's an entirely new way to make such articles as rocket nozzles, crucibles, components for electronic and X-ray use, and parts for atomic energy equipment!

The quality of these pieces is uniformly high. Tolerances can be held to .002 in. or better. The metal loses none of its purity and superior density is achieved.

With the *PLASMARC* Torch, LINDE is equipped to supply you with parts made of, or coated with, refractory metals; or made of a variety of metals combined with non-metals or reinforced plastics. LINDE will also provide a wind-tunnel materials testing service based on this device. For information on this extension of LINDE's well-known Flame-Plating service, write Dept. AW-13, LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N.Y. In Canada: Linde Company, Division of Union Carbide Canada Limited.

The *PLASMARC* Torch employs a non-transferred electric arc to generate such high temperatures that powder or wire fed into the chamber is literally melted. Inert gases flowing continuously carry the metal particles in a plastic state and deposit them on the workpiece at near-sonic speeds. Jets of CO_2 cool the particles instantly to form heat- and erosion-resistant material. Coatings—even on graphite—have an excellent bond. Shapes are built up on machined mandrels, which are then etched away to leave parts such as those shown above.

Linde UNION CARBIDE

"Linde", "Union Carbide" and "Plasmarc" are trade marks of Union Carbide Corporation.

GD60 AND 80 SERIES

GD100 SERIES

LR20B SERIES

Control gases safely, accurately

TO 15,000 PSI AND 50,000 SCFM WITH VICTOR REGULATORS

You get precise regulation of high pressure gases with large flow rates, because Victor employs gas pressure to control the regulating diaphragm. The result is accurate delivery from 5 to 15,000 psi with inlet pressures to 15,000 psi . . . plus ability to obtain flows in excess of 50,000 scfm at maximum inlet and outlet pressures. Chart below shows operating range of standard models.

MODEL NO.	MAX. INLET PSI	MAX. OUTLET PSI	FEATURES	MAX. FLOW SCFM
GD10	3,600	500	Single adjustment regulator control	250
GD30	2,500	2,500	Load & bleed valve control	400
GD31	3,600	3,600	Load & bleed valve control	600
GD61C	2,500	2,500	Load & bleed valve control	170
GD62C	3,600	3,600	Load & bleed valve control	200
GD65	6,000	6,000	Load & bleed valve control	250
GD65C	7,000	7,000	Load & bleed valve control	250
GD80A	5,000	5,000	Load & bleed valve control	500
GD81A	10,000	10,000	Load & bleed valve control	800
GD86R	10,000	10,000	For remote control only	1,200
GD100R	6,000	6,000	For remote control only	20,000
GD100	6,000	6,000	Load & bleed valve control	20,000
GD200	6,000	6,000	Load & bleed valve control	50,000
GD700	7,000	7,000	Single adjustment regulator control; self relieving	250
SR10	3,600	1,000	Small, spring loaded regulator	4
LR20B	7,000	7,000	Spring loaded regulator; self relieving	2
LR20BSS	10,000	10,000	Spring loaded; stainless steel	2
LV10	7,000	7,000	Loader valve control	15
BPR10	7,000	7,000	Back pressure regulator	2

Operating temperature range: −67°F. to +250°F.

. . . Yours for the asking
Take advantage of Victor's long experience with high pressure gas regulation to help solve your special problems involving flow rates, delivery pressures, corrosive fluids and temperature compensation. Write, wire or phone us today. No obligation.

All models listed are field proved. Most are designed for panel mounting or remote control. They regulate all non-corrosive gases, including oxygen. Stainless steel models available for corrosive gases and pressures above 10,000 psi. For complete specifications, write for Victor High Pressure Regulator sheets.

VICTOR® for regulators

VICTOR EQUIPMENT COMPANY MISSILE DIVISION 67

Mfrs. of High Pressure and Large Volume Gas Regulators; welding & cutting equipment; hardfacing rods; blasting nozzles; cobalt & tungsten castings; straight-line and shape cutting machines.

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Circle 13 on Inquiry Card, page 89

J. C. Menzies & Co., Wholly-Owned Subsidiary

use Airco's new Dip Transfer† *CO_2 Process***

for **ALL-POSITION WELDING OF STEEL IN ALL THICKNESSES**

low costs • easy fit up • high speed • very low spatter • no warpage

In welding mild sheet steel manually, there's only *one way to reduce costs and produce high quality welds* at the same time. Airco Dip Transfer CO_2 Process Welding. Let's be specific: –

- The complete Airco Dip Transfer CO_2 package welds in all positions . . . manually!
- Welds are hydrogen-free.
- Virtually ends warpage – only low average currents are used for burn off.
- Creates little or no spatter.
- Handles typical steel joint fit ups.
- No flux needed.
- Penetrates deeply – critical for high quality.
- Welds much faster than flux-based processes.
- Uses money-saving Pureco CO_2 as shielding gas.
- The basic equipment welds all weldable metals.

The Airco Dip Transfer CO_2 Process gives you consistently *high quality* welds at *lower costs* than any other process. For complete information, phone or write your nearest Air Reduction Representative. Ask for the new 24-page "AIRCOMATIC CO_2 WELDING" Catalog.

Pureco CO_2 is supplied by the Pure Carbonic Company, a division of Air Reduction Company, Incorporated.
†Trademark
**Patent Applied For

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A division of Air Reduction Company, Incorporated
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MetalFilm Strain Gages...

each backed with factory technical service

Tatnall MetalFilm Strain Gages for use from sub-zero temperatures to 1800°F are supplied directly by the factory... where all your questions can be answered, and your requests for assistance are promptly met by strain gage experts.

MetalFilm Strain Gages are a unique combination of ultra-thin, precisely controlled alloy foil with plastic or strippable backings. These gages are flexible, temperature compensated, and stabilized. *Many can be applied in less than 5 minutes.*

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For full information and literature about MetalFilm Strain Gages, their specifications, application, and prices, contact our Department AM-6.

TATNALL MEASURING SYSTEMS COMPANY
A SUBSIDIARY OF THE BUDD COMPANY • P. O. BOX 245 • PHOENIXVILLE, PENNSYLVANIA

Budd

New design in Sigma hand welding torches

Here is a new, lightweight torch—only 16 ounces—for manually welding light-gage steels. Sigma ST-2 welds in all positions with no change in control or current settings. Welds .030- to .100-in. sheet, using low-voltage short-arc technique with .020- and .030-in. hard-drawn wire. For 200 amp continuous service.

Balanced design makes handling easy. Service lines enter through rear of handle—a convenience in cramped quarters. Start-stop switch on handle, easy to reach. Nozzle has a 60° curve for maximum weld visibility.

Sigma ST-2 makes high-quality welds at high speed. Seams require no cleaning . . . distortion is at a minimum. Inert gas shielding is economical. Low flow rate—only 10 cu. ft. or less per hour—means even more savings.

Call your nearest LINDE office today for a demonstration of this new Sigma ST-2 torch! Or write Dept. AC-6, LINDE COMPANY, Div. of Union Carbide Corporation, 30 East 42nd Street, New York 17, N.Y. Offices in other principal cities. In Canada: Linde Company, Division of Union Carbide Canada Limited.

Linde TRADE-MARK UNION CARBIDE

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Circle 16 on Inquiry Card, page 89

HIGH-STRENGTH ALUMINUM CASTINGS

Complex machining was avoided on the T-38 canopy supports with castings of high-strength Ductaluminum.
56156
72-156
U.S. AIR FORCE

DUCTALUMINUM CASTINGS TO MIL-C-21180A SAVE NORTHROP $1,500 PER T-38 JET

Using high-strength Ductaluminum castings for three structural canopy supports on the new T-38 supersonic jet trainer saved Northrop $1,500 per ship. The alternative—a fabricated assembly of hog-outs from forgings and extrusions—would have occupied greater space, weighed nine pounds extra, and cost $1,500 more for each aircraft.

Northrop's example proves that high-strength castings with guaranteed mechanical properties (in the *casting*) can be used in place of forgings, extrusions or weldments for structural parts at considerable savings to the manufacturer. Consider these advantages of castings: lower tooling cost, intricate design, cast-in lightening holes and bosses, and rigid, one-piece construction.

Ductaluminum castings produced to MIL-C-21180A (ASG) specification provide the following guaranteed properties* in highly stressed areas.

	UTS	YS	%EL
Ductaluminum 356T	38,000	28,000	6.0
Ductaluminum 356S	42,000	35,000	3.0
Ductaluminum 355	50,000	40,000	3.0

*Higher properties can be guaranteed in castings with favorable design characteristics.

A-3198

Plants at Mahwah, New Jersey and Rivera, California

AMERICAN Brake Shoe COMPANY

LIGHT METALS DEPARTMENT
MAHWAH, NEW JERSEY

Circle 17 on Inquiry Card, page 89

Jet Miracle by **Boeing 707**

Protective Coatings by **Amchem Alodine!**

At Boeing's Seattle and Renton plants giant dipping tanks are utilized to treat unpainted portions of 707 fuselages and engine pods with Amchem Alodine, the superb chemical conversion coating. The amorphous chromate coating imparted to aluminum by Alodine endows this strong light metal with corrosion resistance and adhesion characteristics superior to other chemical treatments. This superiority of Amchem Alodine is needed to withstand the rigorous environments experienced in jet flight.

Alodizing with Alodine is the fastest method of treating aluminum parts uniformly. Savings are realized through reduced costs of electrical power, labor and processing time, fewer rejects. And Amchem technical specialists are always available to render assistance in determining initial requirements, recommending proper equipment, training personnel and following through on quality control.

Follow the industry leaders who specify Alodized with Alodine for a finer end product.

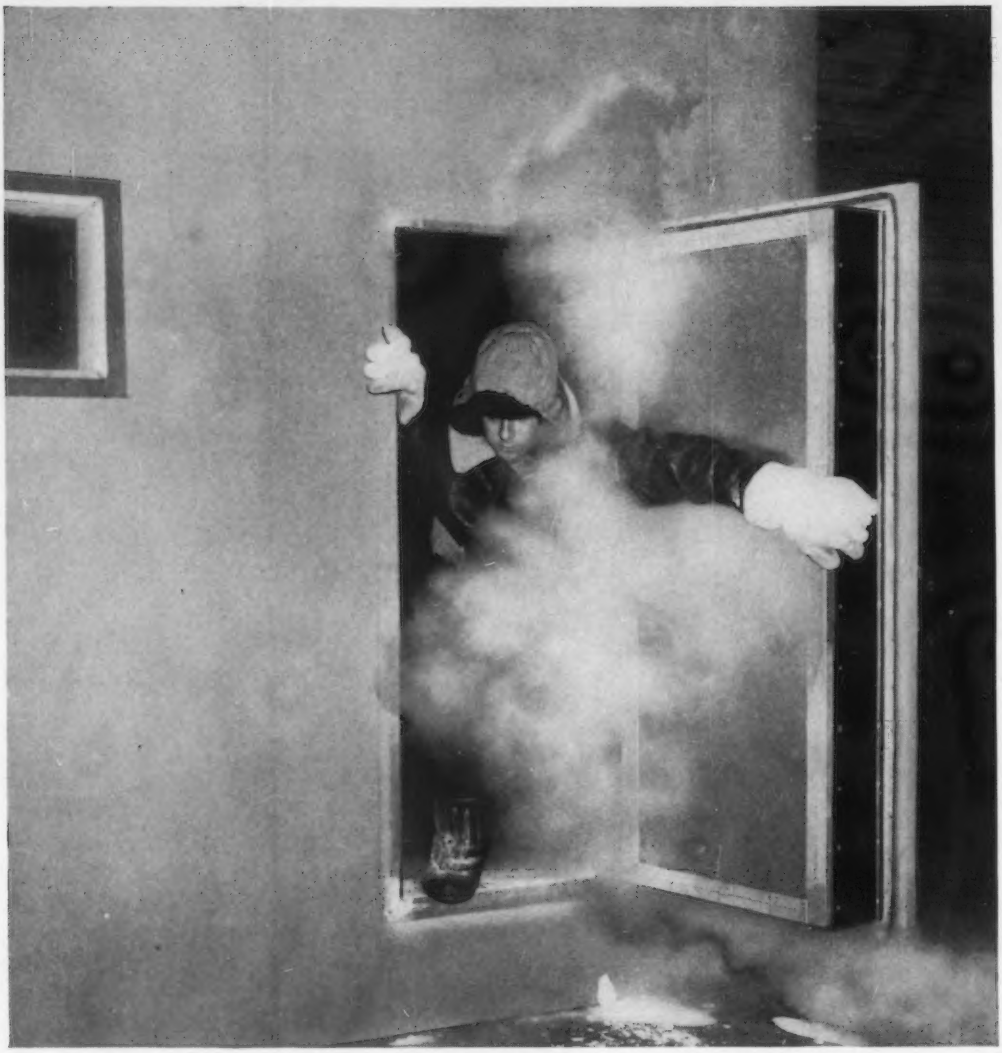
Write for Bulletin 1424B describing specific applications of Amchem Alodine. Contains handy Selection Chart to help you choose the Alodine type suited to your needs.

AMCHEM

ALODINE

another chemical development of
Amchem Products, Inc., Ambler 12, Pa.
(Formerly American Chemical Paint Co.)

Detroit, Mich., St. Joseph, Mo., Niles, Calif., Windsor, Ont. • Amchem and Alodine are registered trademarks of Amchem Products, Inc.



Partial view of a 10′ x 10′ x 35′ low temperature test chamber built by the Mantec Division of Wyle Manufacturing Corp., El Segundo, California. Bulk liquid PURECO CO_2 can bring the interior down to —110° F. in minutes.

PURECO CO_2 puts the *freeze* on Wyle test chambers

Inside this low temperature chamber at Wyle Laboratories, missile and aircraft mobile ground support test units are subjected to temperatures plunging well below arctic fare.

The best refrigerant for this important test job is PURECO CO_2 in bulk liquid or solid form ("DRY-ICE"). It can be ACCURATELY CONTROLLED, is MAINTENANCE-FREE, CONVENIENT, RELIABLE and LOW IN COST.

Wyle standardizes on PURECO CO_2 because PURECO means *dependability of supply* and know-how.

PURECO'S Technical Sales Service is qualified to assist you in adapting CO_2 to any particular refrigeration or inerting application. Call your PURE CARBONIC representative. There are more than 100 PURECO locations from coast to coast.

PURECO CO_2

Pure Carbonic Company

A Division of Air Reduction Company, Incorporated
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(Advertisement)

A REPORT ON THE FIRST SUCCESSFUL PROCESS FOR CHEMICALLY MILLING LIGHT METAL CASTINGS

In high speed jets, rockets, and missiles the price tag on every ounce of excess weight is enormous. Even the use of lightweight aluminum and magnesium alloys wherever possible leaves room for improvement. For while part thickness is often determined by structural requirements, it is frequently a function of the metalworking processes used. Castings, for example, must have sufficient wall thickness to assure sound structure throughout. Thinner sections are generally achieved by machining the parts after casting. This is often an expensive and sometimes impossible task, especially where complex contours or double walls are involved.

Enter Chemical Milling

The first break came when a solution was discovered to the same problem as it affected wrought parts. The solution—familiar to every high school chemistry student—was based on the consumption of metals by powerful reagents. Its successful application to metalworking production presaged significant strides in weight reduction. But when the same techniques were applied to castings, results were extremely poor.

Rolle research immediately began laboratory tests to discover the reason for the failure, and found it often lay *in* the castings. Even minor imperfections in the casting surface unbalanced the process of metal removal—enlarging any defects present. Rolle also found, after much searching, that only certain reagents in certain concentrations—depending on both the part cast and the alloy used—could guarantee success. It has taken almost two years of exhaustive research to refine this process to the extent that it can now take its place as an accepted metalworking technique. Parts can now be designed for casting that could only be constructed by sheet fabrication techniques in the past.

Half The Wall Thickness

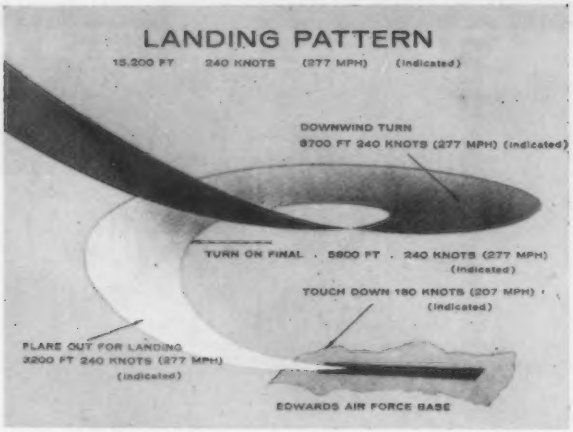
The major advantages of this chemical milling process are pretty much wrapped up in the single figure 0.060"—the wall thickness which Rolle can consistently meet by the process. The importance of this figure is readily comprehended by comparing with it the conventional limit on casting wall thickness—.125". Rigid control techniques, developed in the laboratory, even permit an overall improvement in dimensional tolerances of the part as a result of the chemical milling process. And at the same time, surface finishes of an order of 100 microinches or better can be consistently achieved.

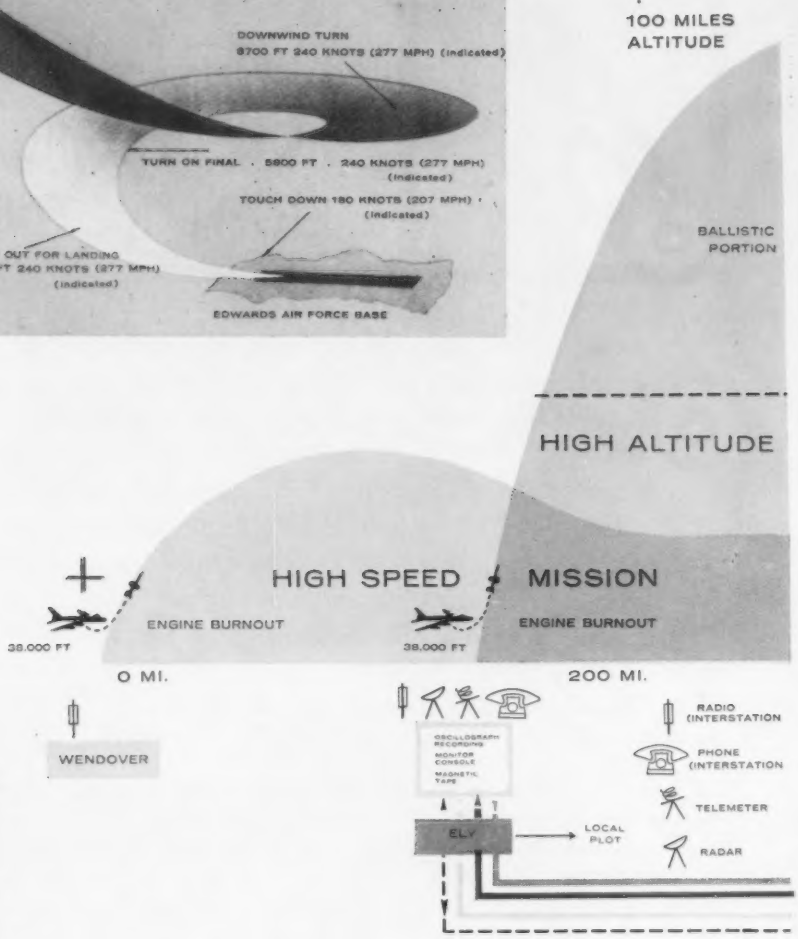
There are two ways you can take advantage of this Rolle technique for chemical milling. One requires the controlled removal of metal from the entire surface area of the part. Allowance can be made in the pattern for holding heavy sections and critical dimensions despite chemical metal removal. The other method, useful where the areas to be lightened are relatively limited, requires masking of those areas not to be etched. The proper technique, of course, can only be decided on the basis of the individual part.

Since the success of chemical milling depends to a considerable extent on the soundness of the casting itself, Rolle cannot promise satisfactory results on any but a Rolle cast part. But Rolle will gladly examine your prints and parts in light of this new technique and make recommendations or quote prices, as you desire. Furthermore, we'll be happy to answer any further questions you may have relevant to chemical milling or the sand, permanent mold, shell mold, or investment casting of aluminum or magnesium alloys. Write Rolle Manufacturing Company, 317 Cannon Avenue, Lansdale, Pa., or call ULysses 5-1171.

ROLLE

Circle 20 on Inquiry Card, page 89


LANDING PATTERN
15,200 FT 240 KNOTS (277 MPH) (Indicated)
DOWNWIND TURN
8700 FT 240 KNOTS (277 MPH) (Indicated)
TURN ON FINAL . 5800 FT . 240 KNOTS (277 MPH)
(Indicated)
TOUCH DOWN 180 KNOTS (207 MPH)
(Indicated)
FLARE OUT FOR LANDING
3200 FT 240 KNOTS (277 MPH)
(Indicated)
EDWARDS AIR FORCE BASE



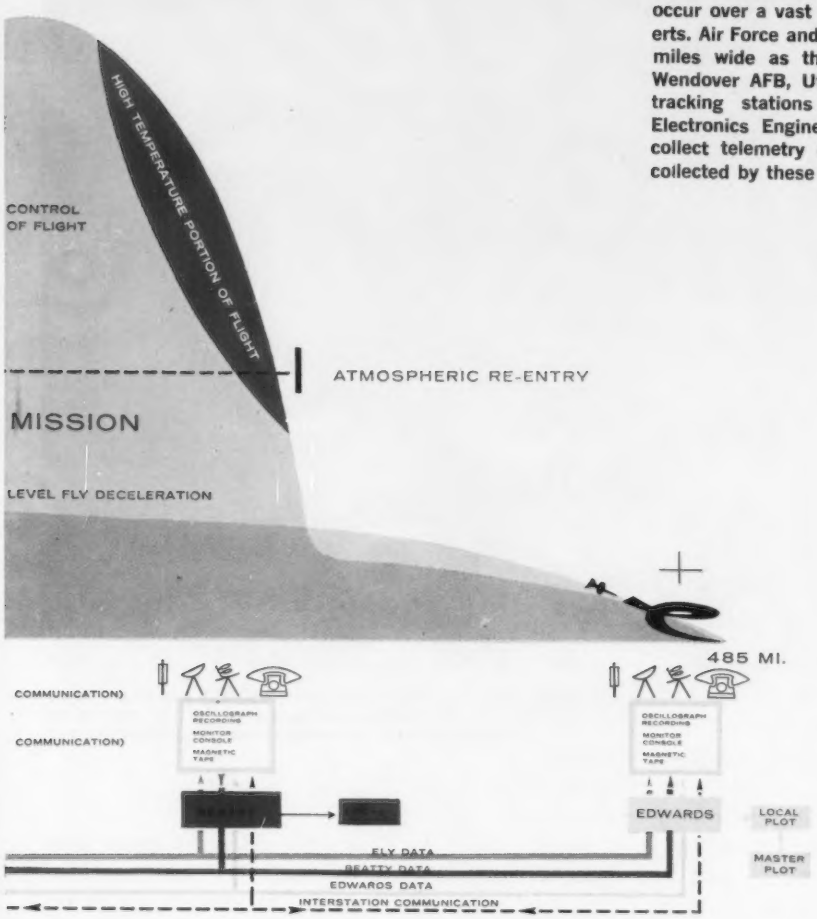
NASA radar technician is shown at radar set that will be used to track X-15 on the High Range. Ground telemetry stations will be used to gather critical flight info.

X-15—a prodigious project

documentation will leave little to doubt; ground telemetry stations can interrogate 600,000 points/min on airframe, engine, and pilot

THE HIGH RANGE

X-15 flights can be separated into two broad categories: maximum altitude, and maximum speed. These flights will occur over a vast expanse of unnamed mountains and deserts. Air Force and NASA have marked a 485-mile flyway 50 miles wide as the X-15 High Range. It stretches from Wendover AFB, Utah, to Edwards AFB, California. Special tracking stations along the way have been built by Electronics Engineering Co. to follow X-15 by radar and collect telemetry data. Maximum bulk data that can be collected by these stations runs to 600,000 items a minute.



North American Aviation's X-15 may be the most significant flight vehicle ever built. Each flight promises to write a new page in man's historic adventure to fly beyond the confines of Earth. And, every aspect of every flight will be precisely recorded on tape. Airborne recording devices will be supplemented by ground telemetry stations along the High Range that stretches 485 mi across some of the most desolate landscape in US. Scrupulous watch will be maintained over every item from pilots heartbeat, to the operation of turbopumps that feed life-giving propellant to X-15's engine.

Manufacturing-wise, the aircraft has been a maximum national effort. Interest-wise it has taken on international proportions. The prodigious glamour is not all attached to the end result — the flight. Engineering, production, and procurement practices are equally dramatic.

X-15 has a wide range of missions. Most important among these are probably:

- Hypersonic maneuvers
- Ballistic flight beyond the atmosphere
- Reentry

Ramifications of these missions stagger the imagination. They include: Physiological consequences of 7G accelerations. Extended periods of weightlessness. The instrumentation challenge of navigating and maneuvering in space with no gravitational or visual reference to earth. The problem of maintaining controlled flight where over 50 years of accumulated knowledge in aerodynamics does not apply. The unprecedented challenge of making an engine, nearly as powerful as Atlas sustainer, safely respond to the wishes of a man sitting no more than 40 ft in front of it.

Tons of data have already been accumulated on problems and their solutions. These will be dwarfed at the end of the twenty flights in which North American will prove out its design.

continued on next page

Nine thousand feet above sea level sits the High Range Station at Ely, Nevada. Light area at foot of mountains in background is a dry-lake emergency-landing strip.

a prodigious project . . . continued

Along the High Range, in stations built by Electronics Engineering Co., "experts" will fly with the pilot by "looking over his shoulder" at telemetered data. These experts include aerodynamicists, flight surgeons, stress engineers, propulsion engineers, etc.

First flight will not be powered. X-15 will be dropped "dry" from as high as B-52 mothership can carry it. Gliding at over 400 mph (TAS) pilot will test pitch, yaw, and roll, perform slips, extend flaps, and in the two minutes that remain effect a landing at Edwards AFB. Rate of descent will be comparable to that of an F-100 with wheels, flaps, brakes, and drag chute extended. Landing pattern (high key) will be at 15,000 ft, downwind turn at 8700 ft and 240 kts. Touchdown will be in the vicinity of 180 kts.

Documentation will leave nothing to doubt when X-15 flies the full 485 mi range. On the High Range, image will be plotted visually, and position recorded on tape in yards distant and altitude.

Continuously - monitoring telemetry will electronically answer over 1000 different "questions" every 1 to 10 seconds. About 656 of these questions will be about temperatures inside and on the surface of the aircraft. Over 100 questions will be asked about strains at various points on the airframe. Pressures will be monitored at 140 different places. Maximum bulk data that can be gathered on existing facilities runs to 600,000 answers a minute.

Data reduction procedures have been stepped up nearly ten times faster than previous methods. Raw data tapes can be fed into machines at Project Datum, Edwards AFB and critical periods in the flight will be found in minutes.

When the pilot calls "light up," and the word goes out to the High Range to "start tapes," the most momentous flight program ever undertaken will begin being documented for posterity.

✦

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of this article can be obtained by writing on company letterhead to
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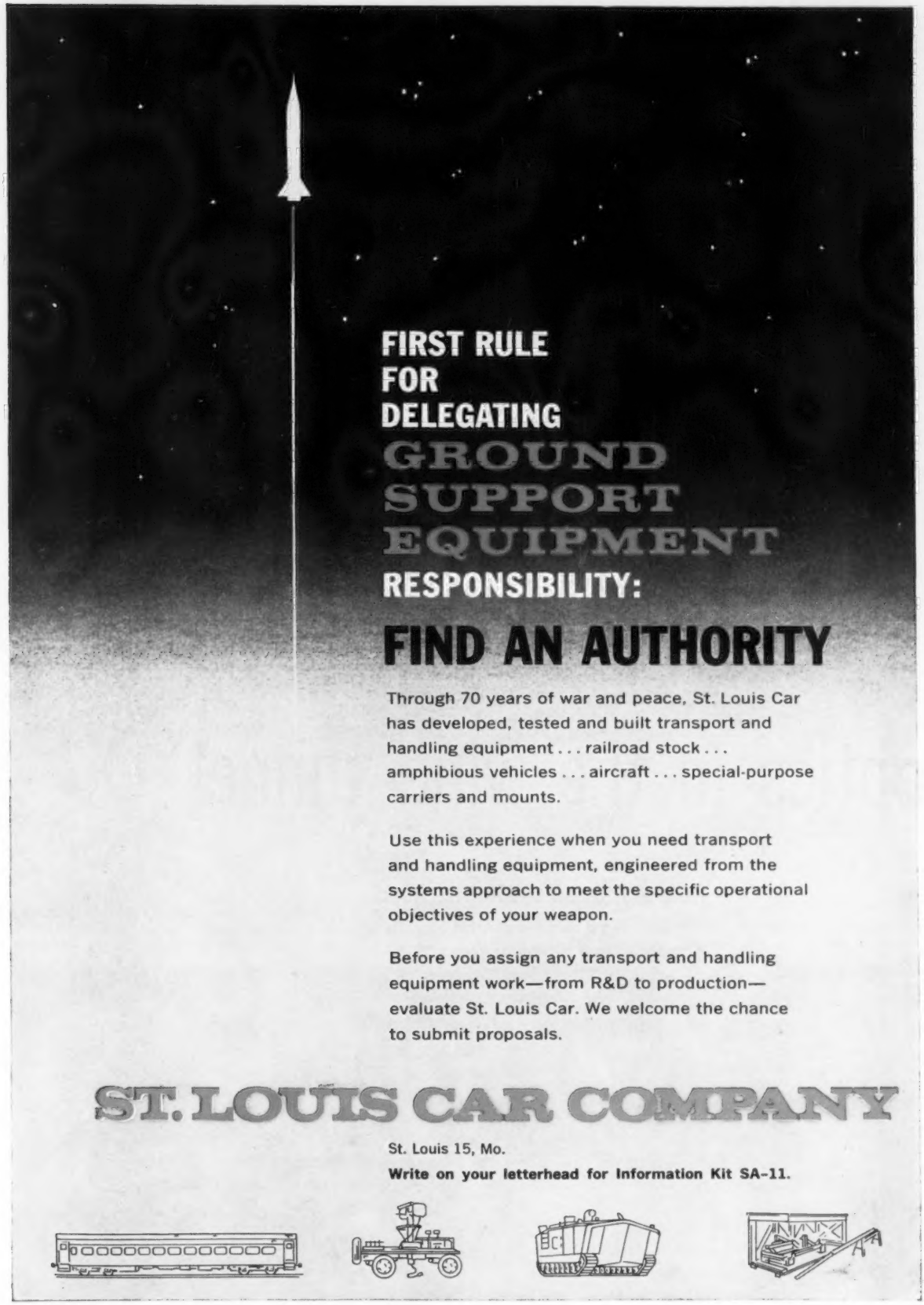

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Through 70 years of war and peace, St. Louis Car has developed, tested and built transport and handling equipment . . . railroad stock . . . amphibious vehicles . . . aircraft . . . special-purpose carriers and mounts.

Use this experience when you need transport and handling equipment, engineered from the systems approach to meet the specific operational objectives of your weapon.

Before you assign any transport and handling equipment work—from R&D to production—evaluate St. Louis Car. We welcome the chance to submit proposals.

ST. LOUIS CAR COMPANY

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Write on your letterhead for Information Kit SA-11.

Circle 21 on Inquiry Card, page 89

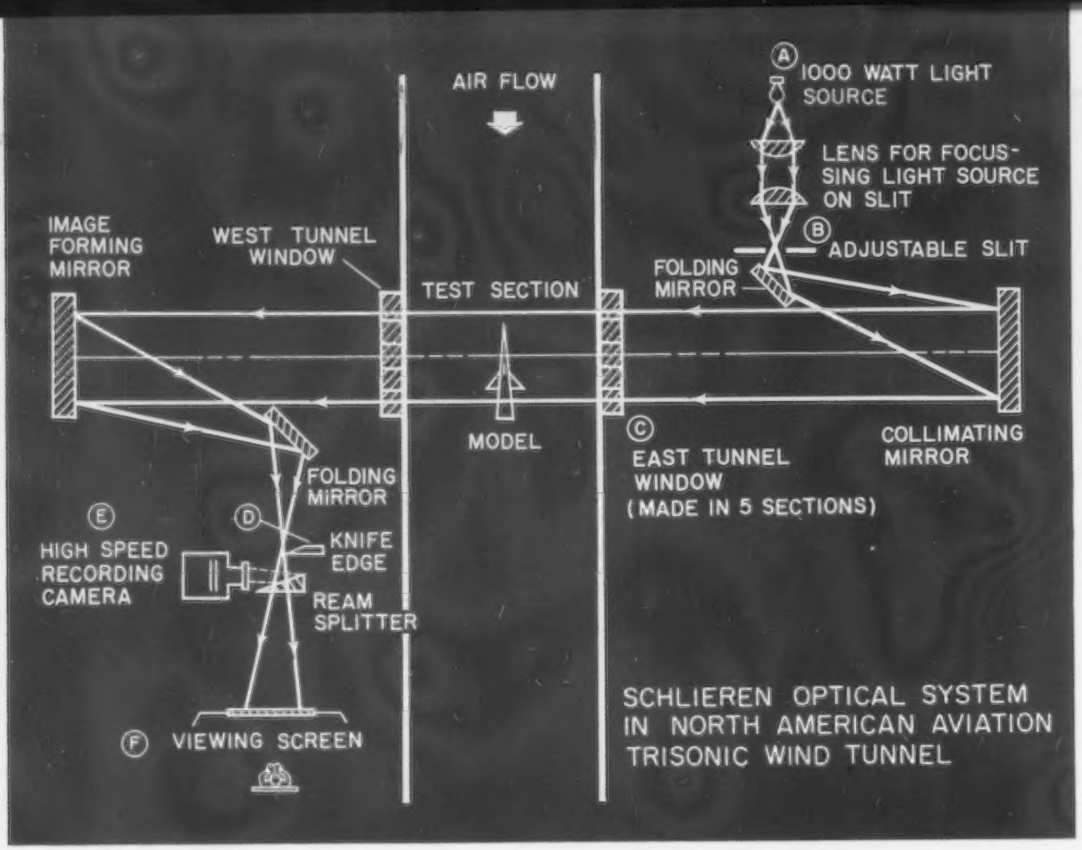


Fig. 1. Schematic layout of optical system in sub-trans-super sonic wind tunnel shows essential elements. (A) 1000-watt mercury light source. (B) Micrometer adjusting slit to control light intensity. (C) Bank of 5 windows 1¼ in. polished optical glass, flush mounted to wall within 0.001 in. (D) Knife edge cuts off fraction of image. (E) Hulcer and Fairchild cameras focus on beam splitter. (F) Operator seated at control panel can observe shock waves.

optics in the wind tunnel

how schlieren system is used to observe and record shock-wave phenomena

by J. Philip Geddes

Shock waves are normally invisible to the naked eye. The schlieren system of optics, however, makes possible the observing and photographing of shock wave formations in supersonic wind tunnels.

Schlieren techniques are most commonly used to show the positions and shapes of density gradients. These are observable in shock and expansion waves, in boundary layers, and in wakes. Using this system, a physical understanding of the flow over a model can be established. A relatively large field of flow can be examined rapidly, without the disturbances produced by exploring instruments.

NAA Trisonic Tunnel

North American Aviation employs a black and white, Toepler schlieren optical system in

the Trisonic wind tunnel at Los Angeles. The installation is shown schematically in Fig. 1. The schlieren system was designed by Precision Technology Inc., and the precision optics were manufactured by Tinsley Labs. for this installation.

A 1000 watt mercury light source is directed through an adjustable slit at the focal point of a 60-in. collimating mirror. The adjustable slit enables variations in the intensity of the light source. The collimating mirror produces a beam of parallel light which passes through optical windows in the wind tunnel walls and crosses the air flow. A 60-in. image mirror, placed behind the flow, gives an image of the source at the focal plane. This image is reflected by a folding mirror into a beam splitter, which directs the image to a recording camera and a viewing screen.

A knife edge, introduced into the focal plane of the image forming mirror, cuts off a fraction of the image before the beam splitter. If the density of the air flow in the tunnel is uniform, across planes normal to the direction of the beam of light, the viewing screen darkens uniformly. When a density gradient occurs normal to the direction of light, the beam is deflected toward the region of high density. This is because light travels more slowly where the density is greater. Thus, the image, composed of light passed through the regions of the density gradient, is displaced relative to the knife edge. Displaced light may be either cut off by the knife edge producing dark streaks on the screen; or, it may be deflected off the knife edge, producing light streaks on the screen. Well defined patterns can be observed on the screen or photographic plate.

System Working Range

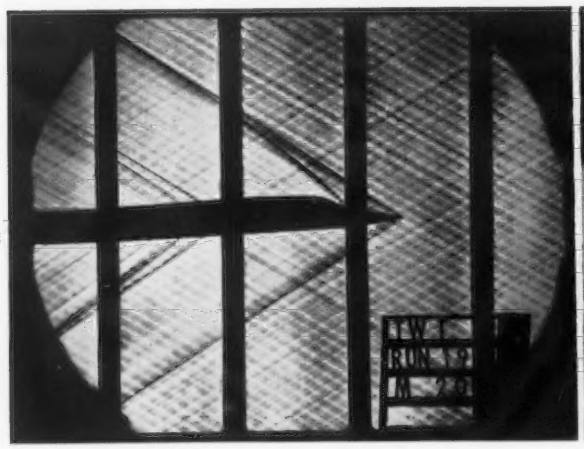
A Toepler schlieren apparatus is sensitive only to deflections of the light in which the image of the source remains partially cut off by the knife edge. If the image is deflected completely onto or away from the knife edge, further deflection produces no change of illumination on the screen or plate. It then is impossible to distinguish between density gradients in the flow, stronger than those corresponding to the limit of the range.

System Uses

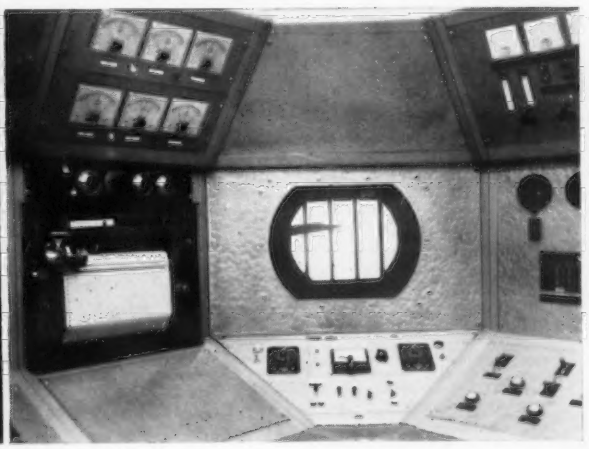
- Studying the point of origin and intensity of shock waves can lead to drag reduction. Slight changes in structural geometry can produce better shock/drag characteristics: the schlieren photograph points the way.
- Shock formations on supersonic ducts are intimately linked to effectiveness of pressure recovery. Viewing shock formations is invaluable in determining correct duct geometry.
- Schlieren observations of shock waves have saved many expensive models from damage or complete destruction.
- Schlieren photographs can be used as documentary evidence of flow speed over a model, as the angle formed by the shock waves is directly related to Mach Number.

◆

Shock waves are seen forming during test of F-107A fuselage at Mach 2. Heavy vertical bars are steel framework supporting optical windows.



Control panel and view screen are shown during static test. Schlieren controls are on center console.



CAN YOU GUESS

The Rupture Pressure Of A ¼" Rupture Disc Made From This Paper-Thin Piece Of Stainless Steel By BS&B?

Rupture Disc Metals

Aluminum	Platinum	Nickel
Silver	Stainless	Monel
Copper	Inconel	

Rupture Discs are performing a wide variety of pressure relief and actuation functions on many of today's most advanced aircraft, missiles, rockets and submarines.

Here we show a few of these functions to illustrate the versatility of the rupture disc's basic principle in application and design. Perhaps one of them will suggest an answer to your pressure control requirements.

ANSWER:

Size	Rupture Pressure PSI @72° F.
¼"	2125
½"	1040
1"	515
1½"	350
2"	205
3"	145
4"	115
6"	85
8"	67
10"	59
12"	50
16"	37
20"	30

Pressure as low as 5 psi can be attained in large diameters; up to 100,000 psi in small sizes.

Sizes from ⅛ inch up.

Service temperatures from sub-zero up to 1000° F.

BS&B will design and fabricate any device to hold the rupture disc to your space and weight specifications.

Rupture disc in larger fitting restrains the thrust of a "Jato Bottle" until the ignited propellant develops a specified pressure. When the desired thrust value pressure is reached, the disc ruptures to provide instantaneous exhaust and resultant thrust. Disc in the small fitting is a safety device for overpressure relief.

Rupture disc in this fitting is used in underwater service. At a specified pressure the disc ruptures to actuate a trigger mechanism.

This device fits in the outer shell of a vacuum insulator vessel containing a fuel component. The rupture disc protects against dangerous pressure build-ups which might occur if the inner shell should break or leak.

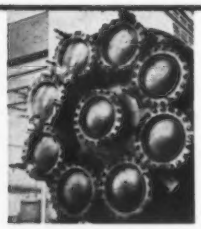
This rupture disc fitting is used on seat ejection mechanisms to lessen shock by the dissipation of excess thrust pressure.

This disc assembly is used to protect against overpressure in air conditioning systems of commercial aircraft.

Here a rupture disc serves as a vital component in power supply of nuclear powered submarine.

Simultaneous rupture of the discs in two of these fittings triggers the mixing of a fuel and oxidizer.

Rupture disc in this tiny fitting protects against overpressure in a missile's hydraulic control system.



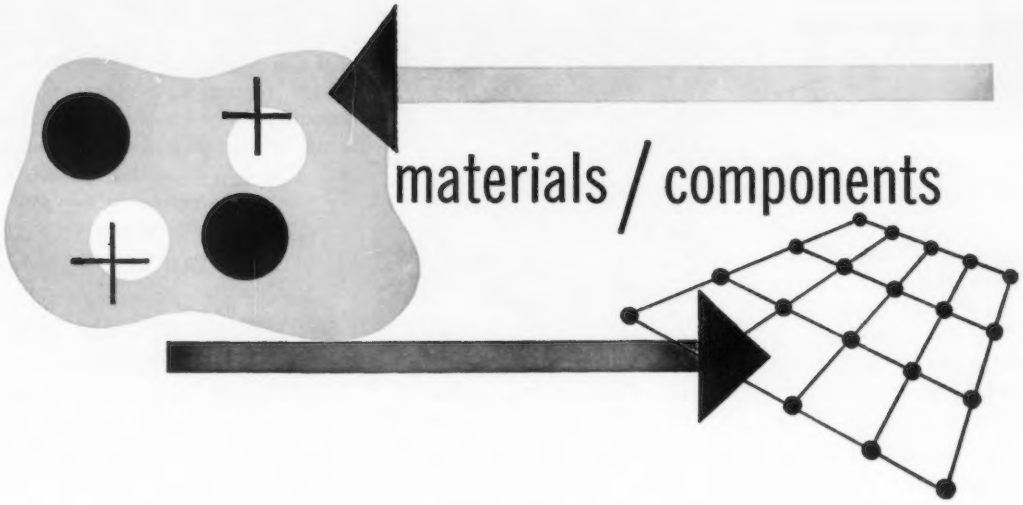
Large diameter (24") Safety Heads are fitted in manifold to provide overpressure protection on this engine test chamber.

EFFICIENCY OVER 60 YEARS RELIABILITY
BS&B
ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

May we suggest further investigation of rupture disc applicability to your pressure control requirements? For engineering consultation call or write . . .

BLACK, SIVALLS & BRYSON, INC.

Safety Head Division, Dept. 2-GC 6
7500 East 12th Street
Kansas City 26, Missouri



MINIATURIZED AMPLIFIER

VHF amplifier with power supply is believed a major advance in miniaturization of airborne electronics equipment.

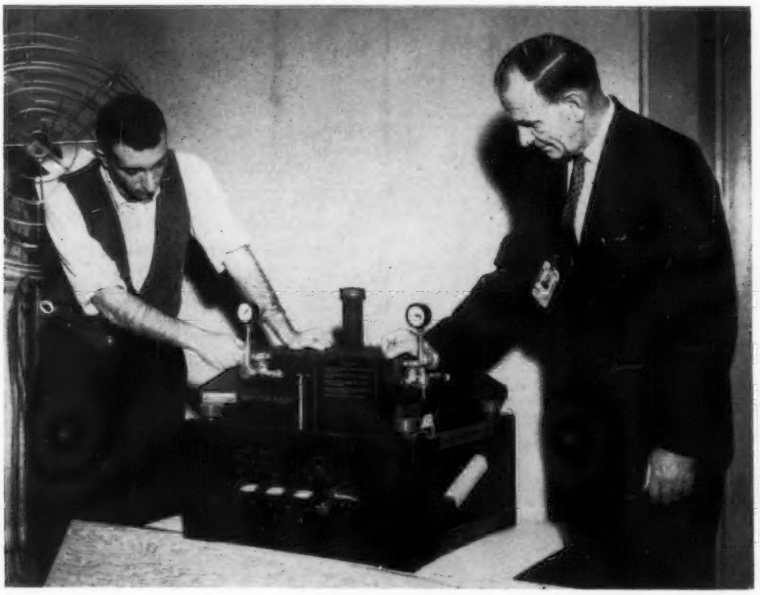
Operated with evaporative cooling techniques, 5 KW output amplifier is two-stage design weighing less than 200 lb. It occupies less than three cu ft. This contrasts with conventional amplifier weighing over 1,000 and requiring six-ft-high relay rack for installation.

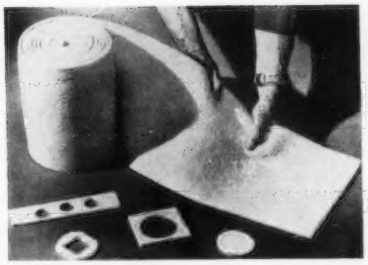
Heat generated internally is conducted into water, causing boiling. Boiling water then serves as a coolant because of vaporization and release of steam.

Unit has been delivered to USAF Cambridge Research Center, Bedford, Mass., for evaluation.

Martin Co.
Baltimore Div.

Circle 70 on postcard for more data





FIBROUS SILICONE RUBBER

"Cohrlastic FSR" is silicone rubber product with tensile and tear strength superior to silicone sponge and foam.

Silicone rubber fibers in mat are organized in random manner. This results in high strength. Product also has inherent permeability. It is available from pilot plant equipment in sheet 14 in. thick nine in. wide, six ft long.

Connecticut Hard Rubber Co.

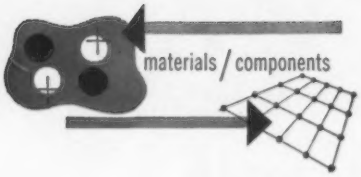
Circle 77 on postcard for more data

ELECTRICAL CONNECTOR

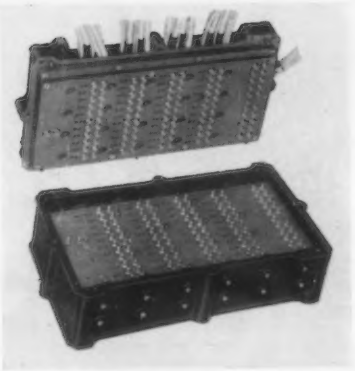
Plug-in connector can make or break any number of electrical circuits simultaneously. Self-aligning, it still makes possible a positive seal of the basic terminal arrangement. First application: on the ground to missile power switching unit of the Snark missile.

Device overcomes shock

continued on next page



and vibration problems by employing a ball and socket principle for its contact pins. Two ball-type pins are connected by a split sleeve held together by two garter springs. The action of the ball-contacts in the sleeve



is that of a universal joint. Self-aligning feature makes unnecessary the straight in-line insertion and extraction of the contact pins. Ground-support cables and plugs can be made as a quick-action type that can be hinged and toggle-locked.

Cole Electric Co.

Circle 72 on postcard for more data

SWITCHING SYSTEM FOR CRYOGENIC LIQUIDS

Glass-aluminum sensing element functions well in cryogenic and most other fluids at temperatures up to 160°F.

Sensor combines with external miniaturized control unit to form a liquid level switching system for low boiling point fluids.

Elements have a glass tip with coefficient of expansion between the barium titanate of

the transducer and the aluminum of the housing. Bonding cement forms leakproof bond between the three, and glass increases the acoustic qualities of element.

Control unit, installed remotely from tank in which sensor is placed, consists of transistor oscillator and relay.

System responds in maximum of 25 milliseconds. Probe, two in. long, ¾ in. diam., 1 oz weight, operates from —320°F to 160°F. Typical control unit has seven cu in. bulk, weighs seven oz, operates between —55°F and 160°F, requires 200 milliwatts power.

Acoustica Associates Inc.

Circle 76 on postcard for more data

continued on page 53

ALL THE PRODUCTION YOU'LL EVER WANT — ALL THE PRECISION YOU'LL EVER NEED
BUT MY WORK INCLUDES THE MANUFACTURE OF—
I KNOW! AND YOU CANNOT POSSIBLY BUY A BETTER MACHINE FOR THE JOB THAN—
THE HAMILTON No. 1-B PRECISION SMALL GEAR HOBBING MACHINE
INVESTIGATE IT! YOU'LL SEE!
SPUR GEARS, WORM GEARS, (up to 6" O.D.) and SPIRAL GEARS
WORMS
SPECIAL TOOTH FORMS
GEAR SECTORS
PINIONS
and FACE GEARS
and BEVEL GEARS (up to 3" O.D.)
2564
ASK for our gear hobber literature packet No. GH-740
Hamilton
PRECISION SMALL-GEAR HOBBING MACHINE
THESE ARE REPRESENTATIVE USERS OF HAMILTON GEAR HOBBING EQUIPMENT
AiResearch Manufacturing Co. • Duncan Electric Co. • Bendix Aviation Corp. • Victor Adding Machine Co. • Lear, Co. • Minneapolis-Honeywell Regulator Co. • Geophysical Machine Works • Hughes Aircraft Co. • Westinghouse Electric Corp. • Rockwell Meters, Inc. • Borg Products Division • Herschede Hall Clock Co. • U. S. Navy Electronics Laboratory • Redstone Arsenal • Smallwood & Son Machine Co. • Link Aviation, Inc. • Bell Aircraft • General Mills • Elgin National Watch Co. • U. S. Naval Gun Factory • Grimes Manufacturing Co. • Texas Instruments, Inc. • McDonnell Aircraft Co. • American Machine & Metals • Stromberg-Carlson Co. • Hamilton Standard • U. S. Gauge Co. • Western Gear Works • Schlumberger Well Surveying Corp. • Douglas Aircraft.
THE HAMILTON TOOL COMPANY • 882 SOUTH NINTH STREET • HAMILTON, OHIO

Circle 23 on Inquiry Card, page 89

(Advertisement)

FIRST in strain measurement

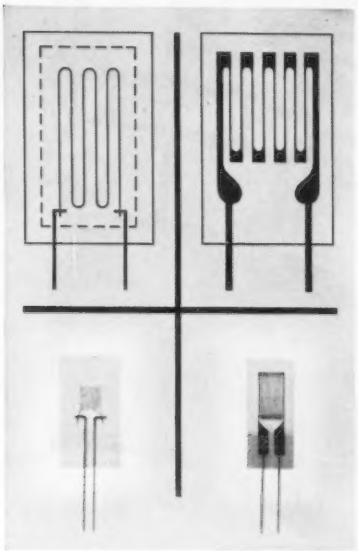
SR-4 BALDWIN BLH LIMA-HAMILTON

STRAIN MEASUREMENT

DATA SHEET No. 1

Useful information about SR-4® strain gages

MEET THE SR-4® BONDED FILAMENT STRAIN GAGE



Bonded wire and bonded foil strain gages are available in a wide range of designs to meet every gaging need. Drawings show typical grid configurations.

Light as a feather, small as a postage stamp, more accurate than a fine micrometer, the bonded filament resistance strain gage has long been accepted by engineers and designers as a virtually indispensable research tool. Its function is to detect the minute strains present at the surface of any solid material, component, or structure under stress, and it is so sensitive that it will react to the pressure of a child's finger on a solid steel column an inch or more in diameter.

Consisting of a looped filament of extremely fine wire or foil, sandwiched between two layers of flexible insulating material, the strain gage is deceptively simple in appearance. Actually, it is the end result of a carefully-controlled, high-precision manufacturing process.

Its operation, as simple in theory as its appearance, depends on the fact that a conductor's electrical resistance changes linearly with longitudinal distortion. The grid of a gage bonded to a surface will stretch or compress slightly with surface strain, thus changing its resistance to a small current passing through it and providing a measure of surface strains as small as one part in a million. Compression of the grid material is possible because of firm bonding to flexible backing layers.

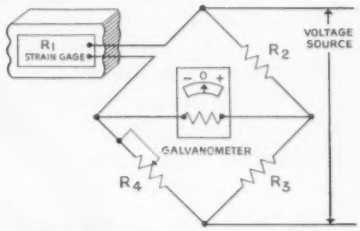
A NEW ERA IN MECHANICAL DESIGN

The SR-4® Bonded Strain Gage was developed in the late 1930s. Designers and engineers soon began to find that this tiny, inexpensive device held the key to some of their most stubborn problems. No longer was it necessary to overdesign critical machine parts and structural members by 400 or 500% to allow for unknown local stresses, to cut-and-try component designs because the exact nature and magnitude of their service loads were not known, or to track down and correct repeated service failures through trial and error methods.

Equally effective in measuring both static and dynamic strains (0 to 50,000 cps and higher), the bonded strain gage quickly found literally thousands of applications in such growing fields as aircraft and automotive design, machine design and construction, and became a familiar tool in virtually every research and development laboratory. It has provided stress analysts with data which made possible lighter, stronger, more efficient turbine blades, connecting rods, gun barrels, locomotives, bridges, dams, artificial limbs, and countless other products of our growing technology. Probably its greatest contribution has been in the aviation field, where it has played an essential role in the development of virtually all modern designs.

THE BASIC STRAIN GAGE CIRCUIT

The change in gage resistance (ΔR) with strain is usually of the order of only a few thousandths of an ohm. To detect and measure these minute changes accurately a modified form of the familiar Wheatstone bridge is usually used. The strain gage, bonded to the surface to be tested, forms one of the resistance arms of the bridge circuit. The bridge is balanced in some manner (e.g., by adjusting R_4) with the gage unstrained. Resistance of the gage changes with the strain. This unbalances the bridge, producing a galvanometer reading proportional to the strain. In practice, static strains are usually measured by rebalancing the bridge while the strain is applied, the calibrated control providing a measure of unit strain in microinches per inch.



Wheatstone bridge provides a simple, highly accurate means of measuring strain gage resistance. Initial balance is achieved by adjusting variable resistor R_4.

Commercial strain indicators, like the transistorized, portable unit shown, include an internal bridge circuit to which the active gage may be connected. When a number of gages are involved in a test, a multichannel switching-and-balancing unit is used to apply the output of each gage in turn to a single indicator and/or recorder.

Transistorized, portable strain indicator permits direct reading of strain in microinches per inch. Operates from self-contained battery or 110 volt, 60 cycle power.

SIGNIFICANCE OF "SR-4®"

"SR-4" is a registered trademark of the Baldwin-Lima-Hamilton Corporation. It is used to identify all of the company's bonded filament strain gages and strain gage instruments.

The S and R are the surname initials of E. E. Simmons and A. C. Ruge, who developed the bonded strain gage independently, but almost simultaneously. The 4 honors the group of four men who initiated commercial manufacture of the strain gage.

Close to a million SR-4® Strain Gages are produced every year. These consist of over 250 different types, for application in virtually every major industry.

There is a right gage for every job. The new B-L-H strain gage catalog contains a wealth of information that could be helpful to you in making the right selection. For a free copy, write Dept. 17-F.

BALDWIN · LIMA · HAMILTON
Electronics & Instrumentation Division
Waltham, Mass.
SR-4® Strain Gages • Transducers • Testing Machines

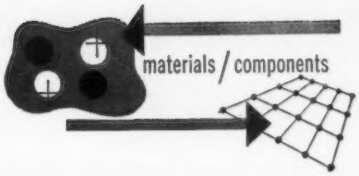
SR-4 BALDWIN BLH LIMA-HAMILTON

VEST POCKET POWER

From vest-pocket nuclear generators for ocean, arctic and wilderness stations—or satellites and space systems—to portable power reactor systems meeting the large-scale requirements of military installations, the products of Martin's five-year nuclear development program are now making news...Developed under the direction of the AEC, the pint-sized 4-pound Martin SNAP III thermo-electric generator was recently singled out for commendation by the scientific community. Meanwhile, Martin is at work on a portable nuclear power plant, designed for transport by air, to provide power and heat for an Air Force installation at Sundance, Wyoming.

MARTIN
BALTIMORE·DENVER·ORLANDO

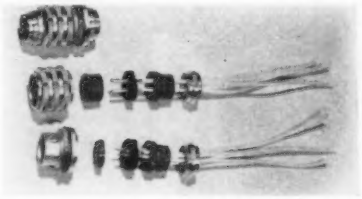
The Nuclear Division is one of the seven divisions of The Martin Company



MINIATURE CONNECTOR

DS series miniature electrical connector features insertable contacts, silicone inserts, and crimp-type terminations replacing solder pots.

Completely environmental, these lightweight connectors are all quick-disconnects. Plugs are equipped with exclusive ball-lock coupling ring.



Connector, with crimp-type terminations, eliminates soldering. Contacts are crimped to the wire and "snapped into" the connector. The DS offers continuous dielectric separation without voids, is completely environmental up to 30 psi, withstands temperature extremes from —100° to 300°F and has a contact retention of 25 lb. Connector meets or exceeds MIL-C-5015.

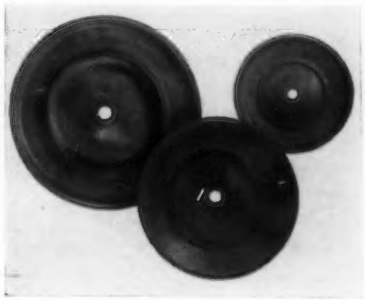
Deutsch Co.

Circle 73 on postcard for more data

DIAPHRAGM SEALS

Precision diaphragm seals for aircraft, missiles, and rockets withstand temperatures

continued on page 56

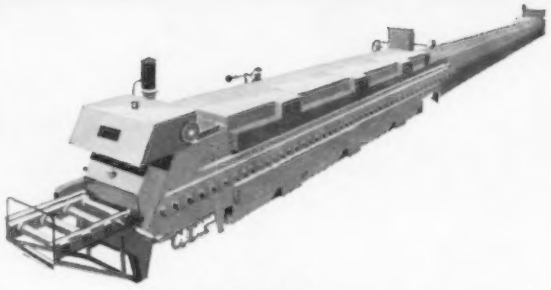


Wherever industry needs heat...

You'll find *LINDBERG* equipment just right for the specific job

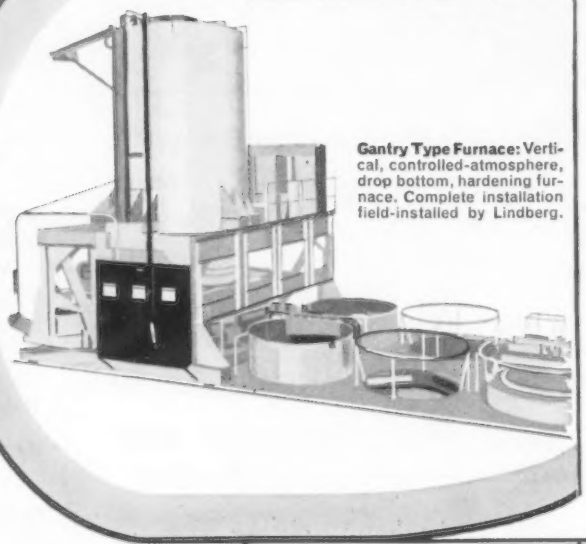
Ceramic Kilns: Gas-fired periodic kiln (shown) with temperature range to 3250° F.

Vertical Type Furnaces: Carburizing and hardening furnace (shown) with CORRTHERM electrical heating elements.



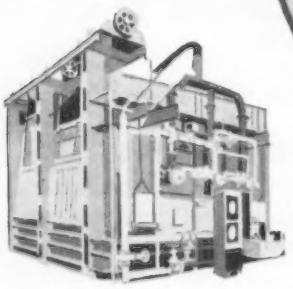
Roller Hearth Furnaces: Continuous electric type (shown) with temperature range 1300° to 2100° F.

Laboratory Equipment: One-unit box furnace (shown), muffle or for non-oxidizing atmosphere with temperature range to 3000° F.

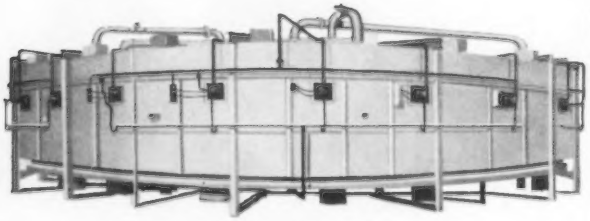


Gantry Type Furnace: Vertical, controlled-atmosphere, drop bottom, hardening furnace. Complete installation field-installed by Lindberg.

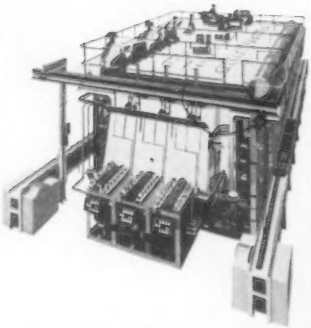
Melting and Holding Furnaces: Electric resistance furnace (shown) with capacities of 750 lbs. to 1500 lbs.



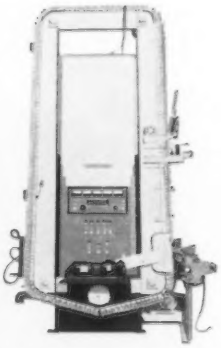
Aluminum Reverberatory Furnaces: Twin-chamber melting and holding furnace (shown) with 45,000 lbs. capacity.



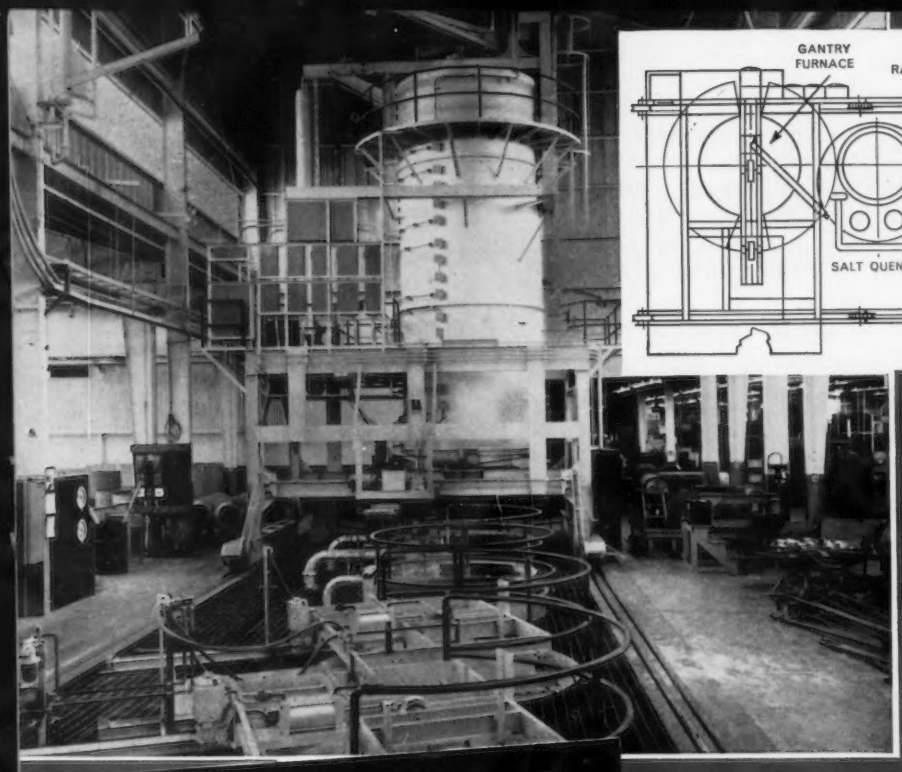
Rotary Hearth Furnaces: Doughnut type field-installed gas-fired furnace (shown) with capacity of 13,000 lbs. per hour.



Multiple Row Pusher Furnaces: Three-row, vertical radiant tube pusher carburizing furnace (Shown). Capacity, 650 lbs. per hour to case depth of 0.055".



High Frequency Units: Vertically designed, completely automatic "HF" unit (Shown) for aluminizing automotive valves.



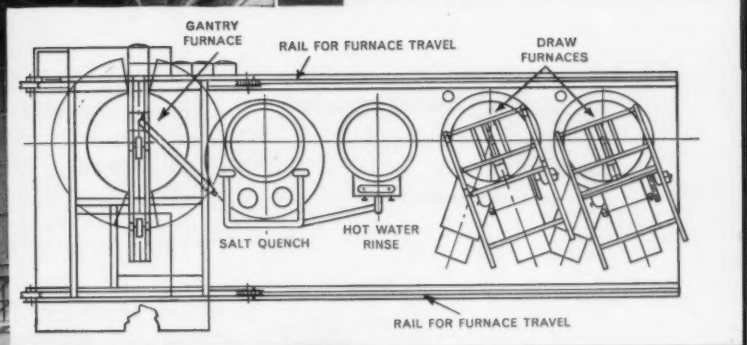
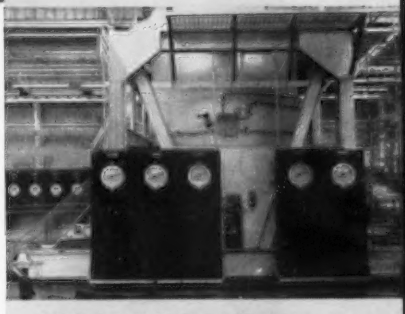


Diagram shows efficient grouping of all elements of the installation.

Furnace is more than 24 feet high. Chain shown at right lifts work into furnace.



Lindberg control panels are conveniently located adjacent to the installation.

Pit has depth of more than 20 feet to accommodate large rocket cases.

Lindberg-Designed

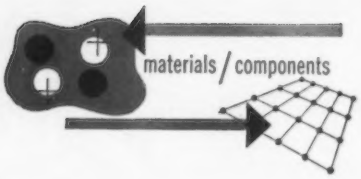
Controlled-Atmosphere Drop Bottom Hardening Furnace for Treating Missile Cases

This remarkable furnace combination was recently installed by Lindberg Industrial Corporation for a prominent missile manufacturer. It was designed by Lindberg engineers, in cooperation with the engineering staff of the manufacturer. The furnace is more than 24 feet high and is capable of heat treating rocket cases more than 5 feet in diameter and 20 feet long. The installation consists of the electric, controlled-atmosphere, Gantry type furnace and two draw furnaces, a hot water wash tank, a salt bath quench and a high nitrogen generator. The Gantry type furnace moves under power over the entire installation to load or unload at any of the pit stations. With this installation, production has been economized and speeded, and the metallurgical qualities of rocket cases improved.

Lindberg equipment and Lindberg planning can help you find the most effective answer to any problem of applying heat to industry. We cover the field, heat treating, melting and holding, tempering, brazing, enameling furnaces, ceramic kilns, high frequency units, and are in the ideal position to recommend just the type of equipment most suitable for your needs. This can be factory built or field-installed in your own plant, fuel-fired or electric. Consult your local Lindberg Field Representative (see the classified phone book) or get in touch with us direct. Lindberg Industrial Division, Lindberg Engineering Company, 2321 West Hubbard Street, Chicago 12, Illinois. Los Angeles Plant: 11937 South Regentview Avenue, at Downey, California.

LINDBERG heat for industry

Circle 26 on Inquiry Card, page 89



from −65°F to 500°F.

Silicones compounded especially for diaphragm applications are combined with popular fabrics such as Dacron and Fiberglass. Result: precision diaphragms with virtual immunity to a broad spectrum of chemical and physical environments.

Pacific Moulded Products Co.

Circle 75 on postcard for more data

HIGH TEMPERATURE CERAMIC COATING

High-temperature-resistant organic-ceramic coating can be applied with ordinary industrial spray equipment.

Called L-154, material offers high dielectric strength, thermal shock resistance as low as −100°F, much greater flexibility than ordinary ceramics, excellent adhesion on metals.

Dyna-Therm Chemical Co.

Circle 71 on postcard for more data

ROCKET MOTOR HEADS

One piece hemispherical rocket motor heads are available in a variety of high-strength metals including titanium and zirconium alloys, and Chromemoly steels.

Heads are formed by hot rolled spinning on exclusive hydraulic spinner.

The head and case are continuous. Bosses can also be formed integrally with the head.

Titanium Fabricators Inc.

Circle 74 on postcard for more data

Valve casting and its MONO-SHELL

Misco's MONO-SHELL process permits manufacture of many new components once avoided by conventional investment casting systems. Castings by MONO-SHELL weighing 25 lbs., 12" dia. x 6" high, poured in air or vacuum by the DOUBLE-V system are commonplace today.

Surface qualities in the as-cast condition average 70-90 R.M.S.

MONO-SHELL permits wide selection of stainless steels and high temperature alloys with improved metallurgical qualities and properties.

Stainless Steels		Hi Temp Alloys		Vacuum Alloys	
310	304	AMS 5382	AM 355	A-286	Udimet 700
410	316	AMS 5385	WI-52	713	GMR 235
347	17-4 PH	AMS 5388	Vascojet 1000	Waspaloy	Rene' 41
431				Udimet 500	

Write us for specific data on alloys produced by MONO-SHELL; or better still, submit your drawings to our Engineering Staff for a value analysis.

Misco Precision Casting Company

Plants in WHITEHALL, MICHIGAN MUSKEGON, MICHIGAN

MISCO

Address inquiries to 124 Gibbs St. WHITEHALL, MICHIGAN Whitehall 2-1515

Sales Offices in Principal Cities

PRODUCERS OF AIRCRAFT AND INDUSTRIAL INVESTMENT CASTINGS

Circle 26 on Inquiry Card, page 89

TWO INCH SPEED TEMPLATE COMPASS

Two new ball bearing action template compasses permit draftsmen to make perfect circles from 1/16 inch to 2 inch diam.

Draftsmen have choice of 69 diameters when using compass.

Draftsman's model is graduated in 1/32 of an inch, student model in 1/16 inch.

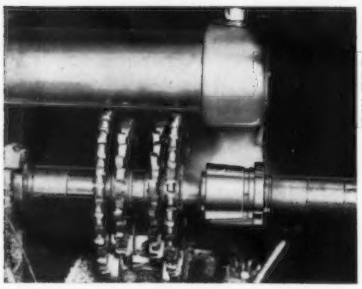
F. & H. Mfg. Co.

Circle 82 on postcard for more data

BEARINGS LUBRICATED

Redesigned Sonnet roller bearing (for milling machine overarm support) permits in-place lubrication.

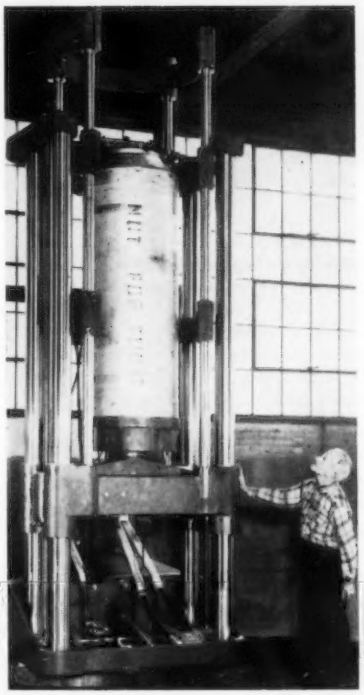
Bearings are easily installed in place of usual bronze types. They are interchangeable, eliminate heating, bearing seizures, twisted arbors. Overarm system does lubricating.



Sonnet Tool & Mfg. Co.

Circle 79 on postcard for more data

ROCKET ENGINE HANDLING MACHINE



Hydraulically - actuated machine handles solid propellant rocket engines during radiological inspection.

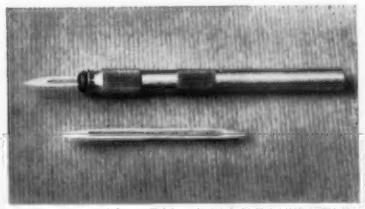
Engines can weigh up to 6000 lb, with five to 10 ft. lengths, and 36 inches diameter. Easy changeover of engines is accomplished by changing fixtures.

With X-ray tube on axis of engine, machine is traversed vertically a distance corresponding to engine length. It is then indexed, traversed vertically, and scanned by the X-ray source. *Barnes & Reinecke Inc.*

Circle 86 on postcard for more data

VEST POCKET SCRAPER AND BURRING TOOL

Outstanding feature of this intrument: cutting edge retracts fully for carrying. Blade adjusts to lengths up to three inches; holder is 4½ in. long.



Tool is well suited to burring operations in the aircraft industry. *Titan Tool Supply Co.*

Circle 91 on postcard for more data

continued on next page

WHEN "ULTRA-CLEANLINESS" IS "ULTRA-CRITICAL"...

...use Curtiss-Wright ULTRASONIC CLEANERS

Our engineers learned long ago, while perfecting their own critical aircraft parts cleaning operations, that building a good ultrasonic cleaner is a precision job that calls for the best in design thinking.

As a result, Curtiss-Wright has developed ultrasonic cleaning equipment with performance features not only important to production, but absolutely essential to the critical cleanliness demands of missile components:

- **Uniform cleaning action—no dead areas**
- **Complete flow control—immediately sweeps all loosened dirt out of the system so it cannot be redeposited on the parts**
- **Maximum usable power—shortens cleaning time**
- **Absolute filtering—easily interchangeable paper filter cartridges with sintered metal tramp filters**
- **Sealed lid design—lowers solvent loss**

Whether you want to clean small or large parts, sub-assemblies or complete assemblies—whether you have a cleaning problem where speed and economic factors are important or wherein extreme cleanliness is the prime consideration, our engineers have the knowledge and experience to supply the equipment you need.

WRITE FOR LITERATURE

PRINCETON DIVISION
CURTISS-WRIGHT
CORPORATION · PRINCETON, N.J.

In Canada contact CANADIAN CURTISS-WRIGHT LIMITED, 1980 SHERBROOKE STREET WEST, MONTREAL, P.Q., CANADA
In countries other than U.S.A. and Canada contact
EXPORT DIVISION, CURTISS-WRIGHT CORPORATION, 50 ROCKEFELLER PLAZA, NEW YORK 20, NEW YORK

RECORDERS FOR TESTING ACCELERATED LOADS

Two self-contained recorders aid design and testing of material for withstanding high acceleration loads of space.

Triaxial Recording Accelerometer (TRA-200) senses and records data on acceleration-time history of motion along mutually perpendicular axis.

Multiple Recording Accelerometer (MRA-440) senses and records data on the response spectrum (shock spectrum) of motion.

TRA is 2 1/16 X 1 11/16 X 1⅞ inches. MRA has 2½ in. diam., 7/16 in. thickness. Former weighs six oz., latter three oz.

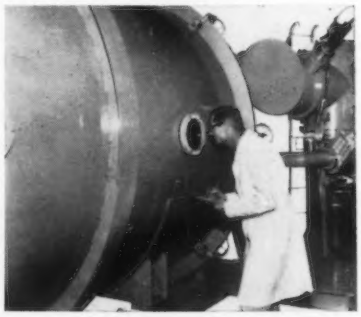
Leach Corp.

Circle 89 on postcard for more data

SPACE ENVIRONMENT

Chamber simulates environmental conditions up to 100 miles altitude.

Large size (eight ft. diam., 15 ft. long) allows testing large equipment.



System is track-mounted. Chamber is easily opened or cantilevered.

Scientific Engineering Lab.

Circle 80 on postcard for more data

continued on page 60

FOR COMPLETE COVERAGE
OF AIRCRAFT AND MISSILE
FASTENER REQUIREMENTS...

Only ESNA® offers all three locking devices

The Red Nylon Locking Collar for maximum performance under severest conditions of vibration, impact, re-use . . . to 250° F.

The Offset Locking Oval for thin-walled, lightweight, miniaturized fasteners . . . 550° F. and 900° F.

The "Z" or Locking Beam standard of the engine industry for high performance at very high temperatures . . . to 1300° F.

Fit the fastener to the application from the only complete line of self-locking fasteners

ESNA

ELASTIC STOP NUT CORPORATION OF AMERICA

It takes more than one locking device to cover the specialized requirements of the aircraft and missile industries. One of the three devices offered by ESNA . . . and only ESNA . . . is sure to have the required qualities for each specific application.

That's half of ESNA's story. The other . . . and equally important half . . . is the tremendous variety of special shapes and sizes available with each locking device. Whatever your fastening requirements, there's an Elastic Stop nut designed to do the job. Mail in the coupon for design information on the full line . . . or recommendations for your particular fastening requirements.

Dept. S28-698, Elastic Stop Nut Corporation of America
2330 Vauxhall Road, Union, New Jersey

Please send me the following free fastening information:

☐ Visual index: A complete pictorial representation of all standard Elastic Stop Nuts.

☐ Here is a drawing of our product. What self-locking fastener would you suggest?

Name_____ Title_____

Firm_____

Street_____

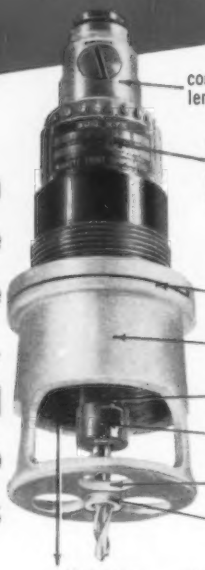
City_____ Zone_____ State_____

Circle 29 on Inquiry Card, page 89

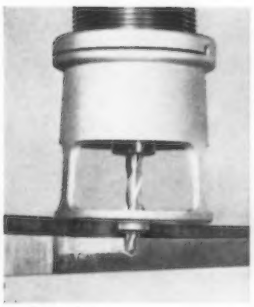
an entirely new kind of metal-cutting tool!!!

THE BUCKEYE Router

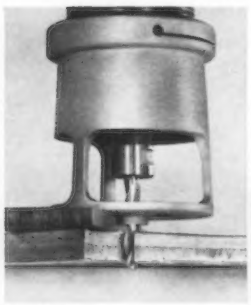
for precision cutting of the most intricate contours in metals, plastics, wood and honeycomb materials


compact, lightweight—length, 7¼" . . weight, 3 lbs.
dependable air motor by Buckeye, producers of the world's first successful rotary air tools.
positive locking, vibration-proof depth adjustment.
corrosion resistant protective plating.
oversize bearing for side thrust cutting force.
full shank, full-grip collet.
open, "clear-view" construction.
template guide.

self-cleaning . . . air exhaust directed downward to expedite chip removal.



PARTIAL CUT . . .



FULL CUT . . .

EVEN HONEYCOMB!

WRITE FOR CATALOG

Write, on your company letterhead please, for your free copy of Catalog G-10, listing all Buckeye air tools—drilling, fastening, abrasive and specials.

INDUSTRIAL AIR TOOLS SINCE 1920

Buckeye Tools CORPORATION

5046 SPRINGBORO PIKE, DAYTON, OHIO

RESISTANCE SOLDERING

No-arc automatic soldering tool eliminates arcing. It provides high-speed, void-free connections critical in the aircraft and missile industry.

Hand-operated unit, particularly adaptable to soldering multiple prong plugs, consists of transformer, hand tool with pressure-operated switch, and a single zirconium-tungsten electrode.

General Electric Co.

Circle 92 on postcard for more data

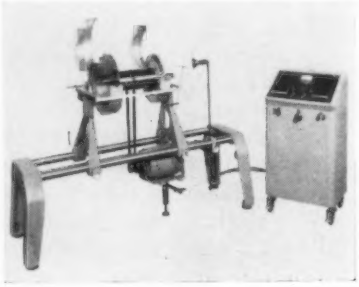
DYNAMIC BALANCER

Dynamic balancer is said to answer 95% of problems encountered in production balancing.

This model (SU-7) has wide work handling capability, and more than a dozen features designed to simplify location of unbalance.

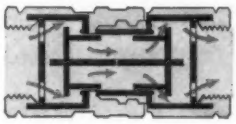
Sensitivity of measurable

continued on page 62

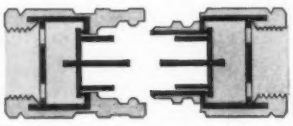


There's a size and type to handle almost anything that flows

TO USE SNAP-TITE VALVED COUPLING:



CONNECT—Full flow instantly



DISCONNECT—No flow instantly

Snap-Tite can provide the right size valved coupling for most any use . . . with quick off-on action wherever coupling or shut-off is required.

"H" series valved couplings for high pressure applications. High resistance to heavy line surge. Sizes from 1/8" through 6". Larger sizes on special order.

"IH" series valved couplings for greater impact in air lines. 1/8" through 1/2".

"E" series valved couplings for vacuum and very low pressure. Recommended for gravity flow. Sizes from 1/8" to 6". Larger sizes on special order.

"T" series valved couplings for hard to handle fluids. The only valved quick-disconnect couplings now on the market for fluid temperatures from −40°F to +400°F. Sizes from 1/2" through 3".

Snap-Tite valved couplings are available with two-way or one-way automatic line shut-off. They are normally furnished in alloy steel. Also available in brass, aluminum, or stainless steel with a variety of finishes.

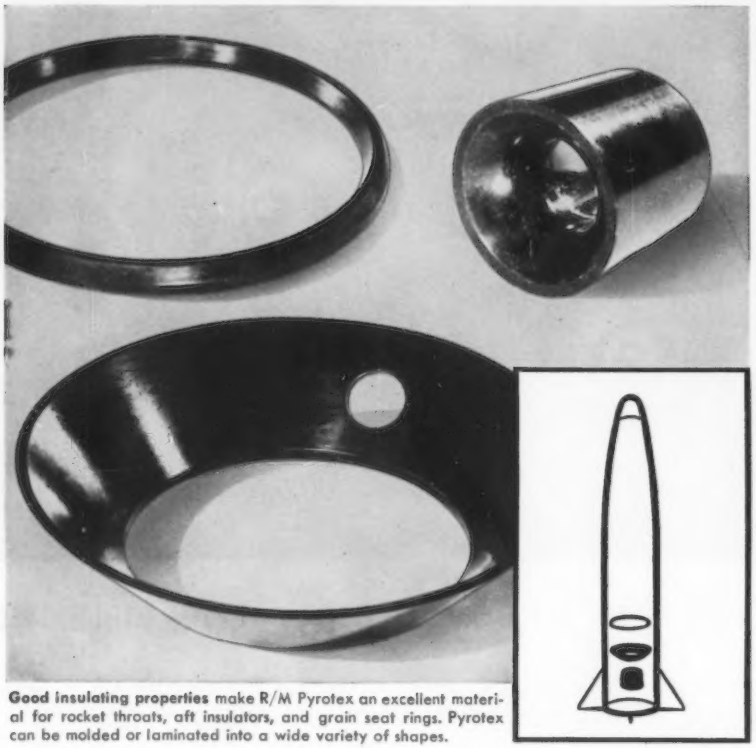
Write for Snap-Tite Catalog No. 58 for more information on Snap-Tite valved couplings.

★Snap-Tite
UNION CITY, PA.

ST-59-02

R/M PYROTEX® REINFORCED PLASTICS ... DEVELOPED TO ENDURE THE FIERY REALM OF THE ROCKET

Light, strong, heat resistant . . . for low-cost, precision fabricated rocket parts— both structural and aerodynamic



Good insulating properties make R/M Pyrotex an excellent material for rocket throats, aft insulators, and grain seat rings. Pyrotex can be molded or laminated into a wide variety of shapes.

Looking for a material that will withstand the elevated temperatures generated by missiles and rockets—internally from burning propellants, externally from aerodynamic heating? Must this material have good insulation and thermal properties, chemical and water resistance, and take a smooth finish? If so, one of R/M's family of Pyrotex reinforced plastics may be the solution to your problem.

The many outstanding thermal and structural features of R/M Pyrotex have led to its use on almost every U.S. missile. It has been fabricated into parts such as nose cones, fins, igniter tubes, rocket throats and sliver traps. Its exceptionally good dimensional stability makes possible mass production to precision standards. And it is low in cost. Write for additional information.

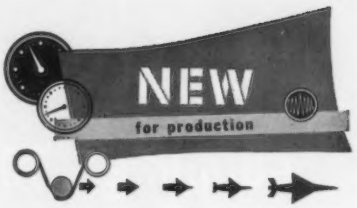
R/M

RAYBESTOS-MANHATTAN, INC.

REINFORCED PLASTICS DEPARTMENT, Manheim, Pa.

FACTORIES: Manheim, Pa.; Bridgeport, Conn.; Paramount, Calif.; No. Charleston, S.C.; Passaic, N.J.; Neenah, Wis.; Crawfordsville, Ind.; Peterborough, Ontario, Canada

RAYBESTOS-MANHATTAN, INC., Asbestos Textiles • Laundry Pads and Covers • Engineered Plastics • Mechanical Packings • Sintered Metal Products • Industrial Rubber • Rubber Covered Equipment • Brake Linings Brake Blocks • Abrasive and Diamond Wheels • Clutch Facings • Industrial Adhesives • Bowling Balls

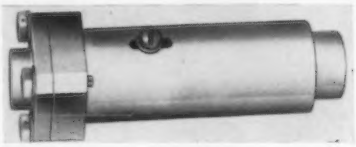


unbalance displacement is specified at 0.00001 in., with a measurable maximum unbalance displacement double amplitude of 0.375 in. A range switch permits direct reading over a range of 1 to 10,000 units.

Micro Balancing Inc.

Circle 78 on postcard for more data

FLOW REGULATOR



A new externally adjustable flow regulator is available for use in laboratories to ascertain exact flow requirements of hydraulic systems. Available pressure ranges: from 5 to 6000 psi. Flow: from .5 gallons per minute to 32 gpm. Temperature range from —65° to 400°F.

Vinson Mfg. Co.

Circle 90 on postcard for more data

PLATING DEPARTMENT IN MINIMUM SPACE

A specially designed utility table makes it easy for plants and machine shops to set up their own selective plating departments in limited space.

Because only small amounts of electrolyte are required, one-liter bottles containing metallo-organic complexes of many different metals may be kept on hand. All these plating solutions, styluses, and other accessories can be stored in the table's drawers and cabinets. The table, 3 ft high, has protective covering of polyvinyl chloride. Foot controls for both hot and cold water free the hands for plating.

Special rectifier, with half-cycle cut-off to prevent arcing, supplies low-voltage d-c.

Table accommodates a low-speed turning head for holding small, symmetrical objects such as bearings. The turning head allows the part to rotate while the plating stylus is rubbed against it for uniform, precision deposit.

Dalic Metachemical Ltd.

Circle 94 on postcard for more data

EMBOSSED LABELS

Hand machine makes on-the-spot embossed labels for use in marking equipment.

"Midgie" labeler is used with wide variety of half-inch-wide tapes. It attaches instantly with special pressure-sensitive adhesive backing.

When letters are embossed, raised area changes color, contrasts with background.

Dymo Corp.

Circle 87 on postcard for more data

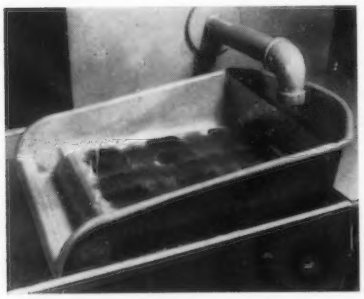
COOLANT CLEANER

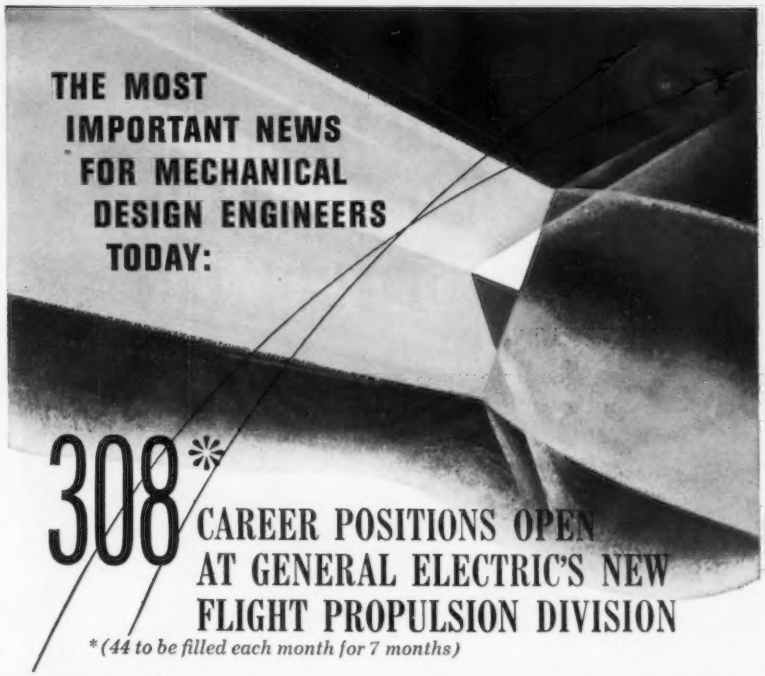
Coolant cleaner is low-cost, manually-operated magnetic separator for removing ferrous contaminants from grinding and other metal working coolants.

Unit consists of Fiberglass tray supported by magnetic retainer plate. Heavy Alnico magnets and gravity tend to collect contaminant in regular rows of tufts. Tufts act as filters to remove the non-ferrous materials.

Kebby Co.

Circle 81 on postcard for more data





308* CAREER POSITIONS OPEN AT GENERAL ELECTRIC'S NEW FLIGHT PROPULSION DIVISION

(44 to be filled each month for 7 months)

It's not just the high number of new jobs open at FPD—but the diversity of the opportunities *within one organization* that's important to your future.

You'll find assignments here in Research, Development, Final Design, Production and Test of almost any type of advanced flight propulsion system.

The project range is as broad as the industry, as the list at the right demonstrates. ▶

Equally important to you is the strong sense of obligation we feel at FPD to give each engineer who joins us the maximum opportunity to develop himself professionally. One of the ways we apply this philosophy is to match—and re-match assignments with a man's abilities and interests, as his career progresses.

Most current positions require background in turbomachinery D&D; some do not. Experience from 3 to 10 years.

(There are also opportunities at Managerial and Specialist levels for Aerodynamicists, EEs, ChEs, Metallurgists, Physicists and Mathematicians.)

For more information about Flight Propulsion Division—and the professional and living advantages of the new Cincinnati, with its fine, uncrowded schools, some 30 active engineering societies, famous symphony orchestra... write for illustrated brochures #50 and #51. *For immediate placement consideration enclose your resume.*

A Partial List of
DIVISION-WIDE PROJECTS AT FPD

...CJ 805 aft fan engine to power Convair 600—**Commercial Engine Dept.**

...J79, famous powerplant of many applications, including F-104A—**Production Engine Dept.**

...J93 development engine with Mach 3 capability, will power B-70 & F-108—**Jet Engine Dept.**

...High Mach, high energy powerplant in early development...exotic propulsion systems using plasma and ion power sources—**Flight Propulsion Laboratory Dept.**

ALSO: A turboshaft project...and a well-advanced VTOL project for vertical and horizontal flight of a fixed wing aircraft... **and other classified projects of unusual interest, with both commercial and military applications.**

Immediate Openings in these Areas

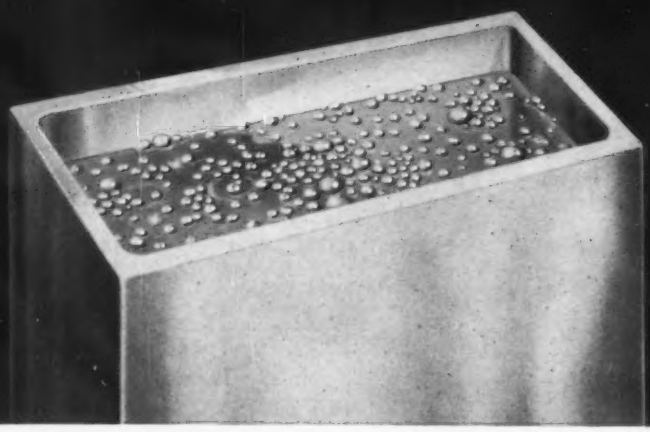
Basic Powerplant Design—Turbomachinery aero • nozzle design • reliability • performance & cycle analysis • installations/applications • component design.

Accessory & Control Systems—Electrical component design • mechanical component design • servomechanisms • reliability.

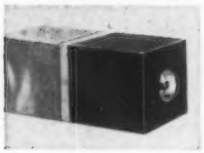
Test, Evaluation & Manufacturing—Test facilities engineering • aerodynamic instrumentation • manufacturing engineering • controls test equipment design.

Address Mr. Mark Peters, Bldg. 100, Dept. 125-MF
FLIGHT PROPULSION DIVISION
GENERAL ELECTRIC
Cincinnati 15, Ohio

ONLY ACOUSTICA ULTRASONIC CLEANERS HAVE MULTIPOWER!



MAJOR BREAKTHROUGH IN ULTRASONIC TECHNOLOGY!



In determining which ultrasonic cleaner to buy, remember that all ultrasonic cleaners are not alike. There is variation in uniformity of cavitation. There is variation in the transducer — and the transducer is the heart of an ultrasonic cleaner. The Multipower transducer developed by Acoustica research, multiplies the power and efficiency of ultrasonic action. Cleaning is faster, labor costs are lower.

Acoustica ultrasonic cleaners are engineered and produced to the finest standards, unequaled in quality and value. Off-the-shelf in capacities from 1 to 75 gal. or custom built to 5000 gal. Expert Acoustica engineers can help you with your cleaning problems.
Send for further information.

NEW YORK
LOS ANGELES

acoustica

LEADER IN ULTRASONIC RESEARCH AND DEVELOPMENT

©1959 By Acoustica Associates, Inc.

Acoustica Associates, Inc.
Dept. AMM, Fairchild Court, Plainview, N. Y.

Send information describing advantages of Acoustica ultrasonic cleaners:

Name_____

Company_____

Address_____

City_____ Zone_____ State_____

CURRENT SOURCE SEMI-CONDUCTORS

Model 5900 constant current source is for measurement and testing of semi-conductors, thermistors, clutches, solenoids, bolometers and many other current sensitive devices.

Current output is 1MA to 100MA determined by four position range switch and a continuous vernier within each range. Voltage output is 0 to 100V determined by load. Safety features include front panel indicator light for high output voltage.

Modifications of basic models include voltage ranges to several thousand volts.

Measurements Research Co.

Circle 83 on postcard for more data

ULTRASONIC TOOL CUTS, DRILLS, SLICES

This bench-model ultrasonic machine tool requires less than 2 x 4 ft of bench space; yet is capable of handling production and experimental machining of hard brittle materials

RE-ENTRY SHIELDS

EST. 1883

WYMAN-GORDON IS FORGING RE-ENTRY SHIELDS

- Copper in production
- Beryllium in limited production
- Reinforced plastics in development

WYMAN-GORDON

FORGING

ALUMINUM MAGNESIUM STEEL TITANIUM BERYLLIUM MOLYBDENUM COLUMBIUM
AND OTHER UNCOMMON MATERIALS

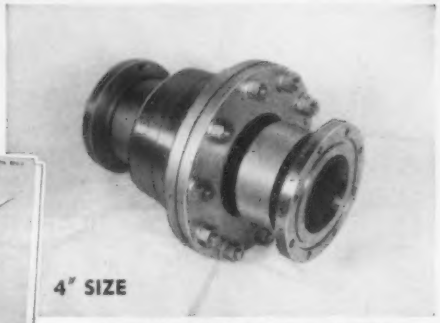
WORCESTER, MASSACHUSETTS

HARVEY, ILLINOIS
DETROIT, MICHIGAN
GRAFTON, MASSACHUSETTS
FORT WORTH, TEXAS
FRANKLIN PARK, ILLINOIS
LOS ANGELES, CALIFORNIA

Circle 31 on Inquiry Card, page 89

BARCO FLEXIBLE JOINTS

For Handling High Energy Fuels . . . .



4" SIZE

4" special stainless steel Barco Flexible Ball Joint for handling liquid oxygen.

. . . . . liquid oxygen, white fuming and red fuming nitric acid, and JP 3, 4, and 5 fuel

6" SIZE

180° flanged 6" Barco Ball Joint for use in loading and unloading line handling liquid propellant.

-special designs for LOX and other Missile Fuels

Extensive design and manufacturing experience is yours to call upon at Barco for the handling of special liquid fuels in the aircraft, rocket, and missile industries:

—Flexible Ball Joints for metal loading lines handling corrosive fluids.

—Special flexible joints with leakproof seals for conveying fluids at low temperatures down to −300° F. Also high temperature designs up to +1000° F.

—Special designs resistant to nuclear energy radiation.

Barco joints provide flexibility *unlimited* for piping and tubing. Our engineers will be glad to work with you on special problems and assist with recommendations.

Flexible Hydraulic Lines for Missiles, Aircraft

MISSILE LAUNCHER HYDRAULIC ASSEMBLY

Barco produces high pressure self-aligning swivel joint and tubing assemblies for hydraulic pressures to 4,000 psi, and higher. Also a wide selection of standard and special swivel joints and assemblies for launching and flight gear. Sizes ¼" to 1".

ASK FOR NEW CATALOG 269-A.

BARCO *Serving Industry Since 1908*
MANUFACTURING CO., 565G Hough St., Barrington, Ill.

AIRCRAFT DIVISION

with great accuracy and economy.

Effective machining area ranges from 1/64 in. to 1 in. for materials such as germanium, silicon, ferrite, hardened steel and carbide.

Designated the Model 200-B2, tool utilizes a magnetostrictive transducer to provide up to 25,000 strokes per second.

Typical operations include cutting, drilling, engraving, slicing, dicing, and production of complex shapes and forms.

The Sheffield Corp.

Circle 88 on postcard for more data

HIGH SPEED DRILLS

Advance in drilling practice is the so-called "Cold Point" drill.

Among the unique design features: use of a carbide insert at the tip of the drill; a single oil passage through the drill and shank; adoption of negative rake for the cutting edges at the tip.

Experimental work demonstrated tool's utility in drilling the gamut of the so-called exotic metals and alloys at extremely high rates of feed. It goes through tough boiler plate in a matter of seconds producing a fine finish.

The drill also is recommended for producing deep holes —those that usually require gun-drilling and part-way drilling—in a single pass.

Mossberg Inc.

Circle 84 on postcard for more data

SPINDLES FOR ELECTROLYTIC MACHINING

Machine tool equipment can now be converted to electrolytic finish machining on a production basis.

Illustration shows Spindle, direct motorized type, 7½ hp, with 3600, 1800, 1200, and 600 rpm. Its slip-ring is designed for 3000 amp power supply. Slide arrangement has exposed ways.

Electrolytic metal removal is accomplished by D. C. electric current delivered by a power supply that converts A. C. current from an ordinary power source to low voltage, high amperage D. C. current.

Standard Electrical Tool Co.

Circle 93 on postcard for more data

GAGE EXAMINES WALLS OF BORES, WALLS, TUBES

An optical spindle, mounted on a precision ground base is used with a standard illuminated microscope. The part is placed on the correct size optical spindle. The microscope, focused on the reflector of the spindle, reveals the wall's condition.

Solrac, Inc.

Circle 85 on postcard for more data

This can't be FIREBAN...:

New Taylor FIREBAN 321 Laminated Plastic is self-extinguishing in only 3 seconds

Electrical faults in appliances, TV sets, radios, motors and other electrical devices frequently lead to fires—and these fires lead to complete destruction of the equipment, sometimes extensive damage to the facilities surrounding it. Taylor FIREBAN 321 is designed to retard fire. Self-extinguishing in only 3 seconds—it is an effective barrier against the spread of flame. In addition, this flame-retardant laminated plastic has excellent moisture resistance, excellent electrical resistance after exposure to high humidity, and good mechanical properties; also offers low dielectric losses. These properties help prevent the electrical faults that lead to fires. Write TAYLOR FIBRE CO., Norristown 50, Pa., for complete details.

Taylor

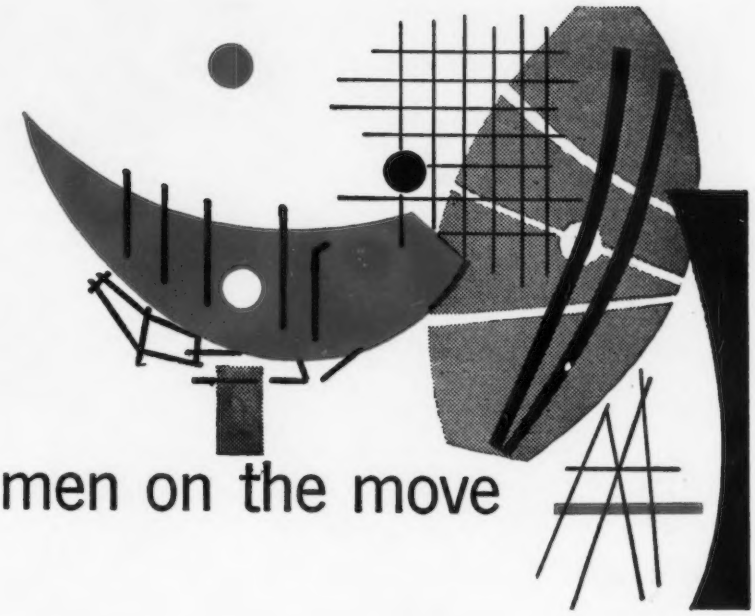
LAMINATED PLASTICS VULCANIZED FIBRE

SPIN FORGE A MISSILE NOSE CONE IN 7½ MINUTES

Duplicate that nose cone in absolute detail thousands of times and waste no metal. It can be done; but by no other method and by no other machine than a Hufford Spin Forge. These massive, fully automated, precision tools can produce most surface-of-revolution shapes within a tolerance of—.002, up to a diameter of 6 feet, employing hardest metals of varying or constant thickness from .030" to 1". A giant step forward to assist you in meeting urgent production requirements, Hufford Spin Forges may be seen performing daily production schedules at the Marquardt Aircraft Utah facility or at our own El Segundo plant. Additional units are currently in design and construction stages. For detailed information, please write The Hufford Corporation, 1700 E. Grand Avenue; El Segundo, California...a division of The Siegler Corporation.

HUFFORD

h 100



men on the move

JACK GRAY, promoted to senior contract administrator for Temco Aircraft Corp.

CHARLES P. BOEGLI, appointed supervisory engineer for the Cincinnati division of Bendix Aviation Corp.

ROBERT J. WRIGHT, named director of marketing for the Mechanical Div. of General Mills.

STEPHEN J. JATRAS, named executive asst. to the vice president and acting director of marketing at Lockheed's new Electronics and Avionics Div. HOWARD S. HAGEN, appointed director of industrial relations at the new division.

ROY R. BREWTON, named vice president and controller, Convair Div., General Dynamics Corp. T. J. SULLIVAN, appointed assistant division manager-contracts, customer service and material at Convair.

ALLEN F. DONOVAN, a vice president, has been named director of Advanced Systems Planning for Space Technology Laboratories.

E. M. HUMPHREY has assumed the newly created post of sales manager of the Goodyear Tire & Rubber Company's Aviation Products Div., Akron, O.

R. J. PFEIFFER, appointed manager of commercial aircraft marketing, North American Aviation, Inc.

THEODORE W. SHIDLER, JR., appointed manager of marketing at General Electric's Small Aircraft Engine Dept., Lynn, Mass.

HARRY S. MYERS, JR. appointed Special Asst. to the Vice President, Engineering, Aerojet General Corp. DR. ADOLPH OBERTH has joined the Solid-propellant Research and Development staff of Aerojet-General's Solid Rocket Plant in Sacramento. DR. ROBERT F. BRODSKY has joined the Systems Div. as manager, Engineering Services Dept., Technical Staff. TOM SPRAGUE, appointed to the public relations staff at the Sacramento Plants.

JACK F. LEPRE, appointed vice president of Reeves Instrument Co., subsidiary of Dynamics Corp. of America.

M. E. CAPOUCH, promoted to manager of distribution and availability; WILLIAM H. GUTERL, promoted to manager of marketing at American Steel & Wire Div., U. S. Steel.

DR. ERVIN H. BRAMHALL, named chief of weapon systems analysis at Solar Aircraft Co. CYRUS C. HAYNIE, named assistant to the plant manager at the San Diego plant.

K. BUCHELE, appointed chief of quality control at the Douglas Aircraft Co., Santa Monica Div.

GEORGE S. COOKE, appointed assistant director of European operations at the Martin Co. European Headquarters, Wiesbaden, Germany.

ALFRED C. HARRIS has joined Commercial Shearing & Stamping Co., Youngstown, as Mgr. of Sales, Rotoform Products.

R. B. JOHNSON, JR., appointed manager, marketing, of General Electric's Flight Propulsion Laboratory Dept., Evendale, O.

BOYD T. MARSHALL, promoted from vice president—engineering program development to vice president—general manager of the Technical Products Div., Waste King Corp.

JAY P. SELLICK, appointed assistant vice president, United Aircraft Products, Dayton, O.

DAVID D. MUNRO, 3rd, appointed manager for the electrical and electronic laboratories, Commonwealth Engineering Co.

DR. HAROLD L. GARBARINO joined Magnaflux Corp. as chief engineer-electronics.

Dr. Ervin H. Bramhall
Solar Aircraft

Cyrus C. Haynie
Solar Aircraft

Alfred C. Harris
Commercial Shearing
& Stamping Co.

R. B. Johnson, Jr.
General Electric

David D. Munro 3rd
Commonwealth
Engineering

Dr. Harold L.
Garbarino
Magnaflux

← Circle 59 on Inquiry Card, page 89

ACTUAL SIZE
DRIVE SPROCKETS
FOR PERFORATED TAPE
These drive sprockets are typical of the production of high precision machine parts considered a specialty at LaVezzi. They can be manufactured to your specifications, held to extreme tolerances on pin diameter and registration, wheel diameter and concentricity, and can include hardened steel pins. The program on which you are working may need parts of this quality and we invite your quotation requests. Write for brochure today.
LaVezzi MACHINE WORKS
4635 WEST LAKE ST., CHICAGO, ILLINOIS
Circle 39 on Inquiry Card, page 89

AIRETOOL PNEUMATIC PRODUCTION TOOLS...

...small but mighty

Take Airetool pneumatic drills, for instance. Their high-torque air motors assure fast, clean drilling, yet these tools are compact, lightweight. Easily handled in close quarters. 3/32, 3/16, 1/4, 1/2, 5/8 and 3/4" models. Airetool angle head drills and midget grinders give this same efficient combination of size and power. Another good example is Airetool 500-V sander. Uses 7" flexible disc, weighs just 4 5/8 lbs. Write for Bulletin 67.

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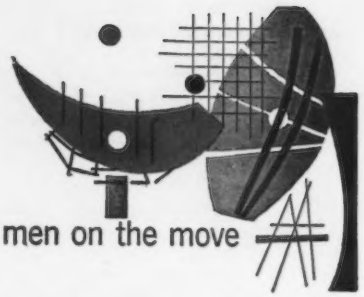
REPRESENTATIVES in principal cities of U.S.A., Canada, Mexico, South America, England, Europe, Puerto Rico, Italy, Japan, Hawaii
EUROPEAN PLANT: Vlaardingen, The Netherlands
CANADIAN PLANT: Brantford, Ontario

AIRETOOL
MANUFACTURING COMPANY
SPRINGFIELD OHIO
30 years experience in pneumatic tools



MICHAEL J. MACDONALD, appointed director of sales, Craig Systems, Inc.

COL. GREGORY "PAPPY" BOYINGTON, USMC RET., appointed vice-president—public relations for Coast Pro-Seal & Mfg. Co.

DR. JACK E. FROEHLICH has been named vice president in charge of special projects for Alpha Corp.

FRANK H. SCOTT assumes the newly created position of field sales manager of the Janitrol Aircraft Div., Surface Combustion Corp.

DR. RICHARD H. VALENTINE has become director of research and development with New Departure Div. of General Motors Corp.

ROBERT P. DODDS, appointed district representative at the San Diego office, Vickers, Inc.

Chadwick M. Bowlin
Kaynar Mfg. Co.

Richard W. Hodgson
Arnoux

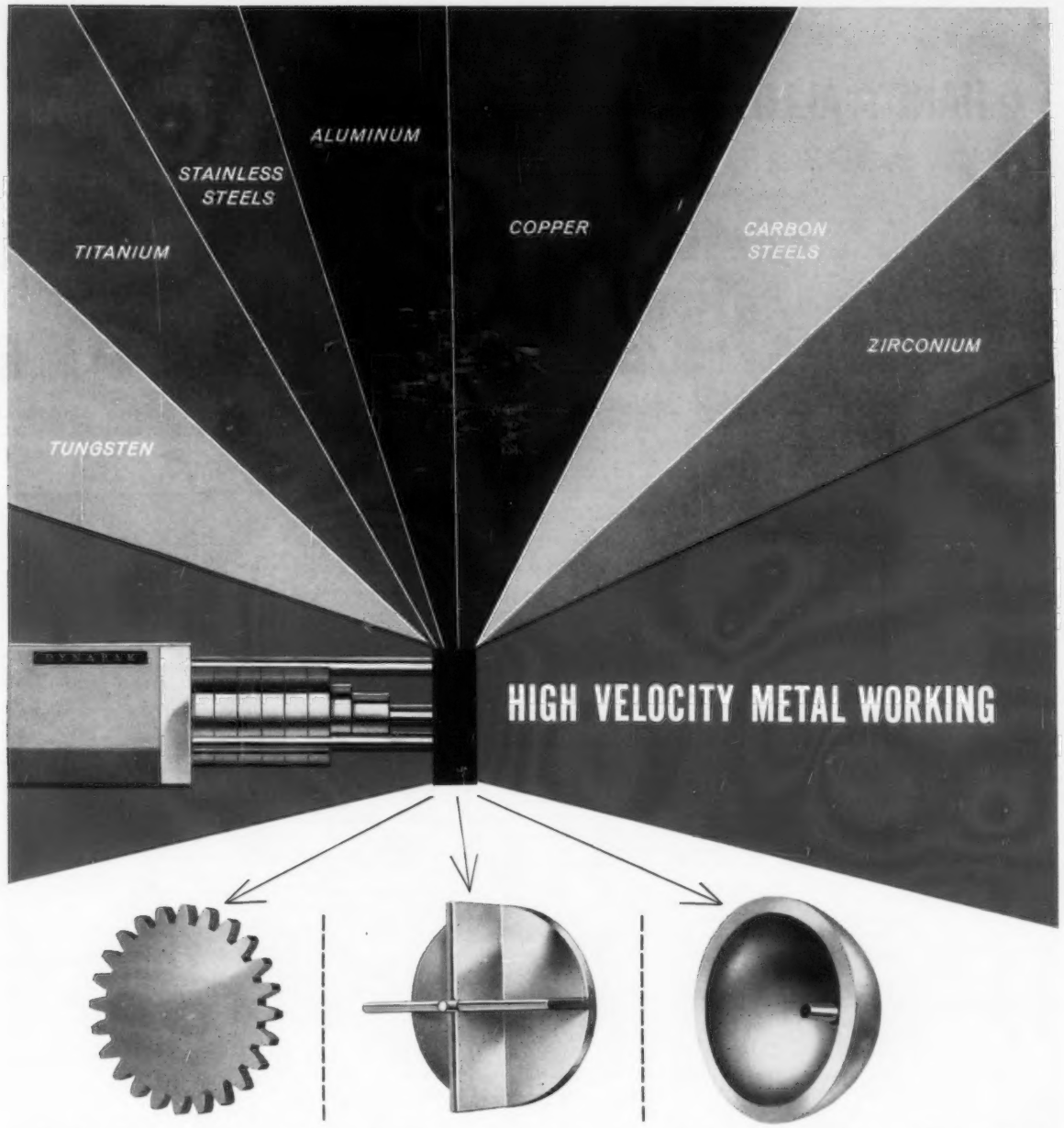
CHADWICK M. BOWLIN, appointed to the sales staff, Kaylock Div., Kaynar Mfg. Co.

RICHARD W. HODGSON, appointed president of Arnoux Corp.

FRANK J. VLASATY, appointed director of research engineering at Size Control Co., Div. of American Gage & Machine Co.

T. A. SANDSTROM, appointed to the newly created position of assistant division manager, Kolcast Industries Div., Thompson Ramo Wooldridge, Inc.

DR. WILLIAM EWART WILLIAMS has been elected to the board of directors of the Bulova Research and Development Laboratories.



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The ability of DYNAPAK high velocity metal working machine tools to forge, form or extrude intricate shapes to precision tolerances from common or high strength metals, offers new solutions for complex problems of design and manufacture.

THE DESIGN ENGINEER will find a new degree of freedom in design. He is no longer confined by the limitations of conventional forming techniques. He can now more nearly specify the ideal materials, shapes, and tolerances.

THE PRODUCTION ENGINEER can often accomplish, in a single operation and with simplified tooling, what would otherwise require multiple operations and complex tooling. With DYNAPAK, management can realize a substantial long-term advantage in capital investment.

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Circle 41 on Inquiry Card, page 89

(Advertisement)

HANDY ALLOY DATA SHEET

HANDY & HARMAN
ENGINEERING DEPARTMENT
82 FULTON STREET, NEW YORK 38, N. Y.

ALLOY LIST

Handy & Harman Silver Brazing Alloys

...The COMPLETE line that meets all specifications and production needs

Need to join any combinations of metals—ferrous and nonferrous? Investigate the vast number of products, assemblies and parts that are being joined better by silver brazing alloys. Handy & Harman, the Number One Source of, and Authority On Brazing Alloys and Methods makes—and makes readily available—the following silver brazing alloys:

HANDY & HARMAN SILVER BRAZING ALLOYS

NAME		SILVER	COPPER	ZINC	OTHER	MELTING POINT °F	FLOW POINT °F	TROY OUNCES PER CU. IN.
EASY-FLO		50%	15½%	16½%	(18% Cd.)	1160	1175	5.00
EASY-FLO #3		50	15½	15½	(16% Cd. 3% Ni.)	1170	1270	5.00
EASY-FLO 45		45	15	16	(24% Cd.)	1125	1145	4.92
EASY-FLO 35		35	26	21	(18% Cd.)	1125	1295	4.90
SIL-FOS		15	80	—	(5% P.)	1185	1300	4.45
SIL-FOS 5		5	88.75	—	(6.25% P.)	1185	1300	4.37
NEW NAME	**FORMER NAME**	**SILVER**	**COPPER**	**ZINC**		**MELTING POINT °F**	**FLOW POINT °F**	**TROY OUNCES PER CU. IN.**
BRAZE TEC*	TEC*	5	—	—	(95% Cd.)	640	740	4.60
" 056*	TEC-Z*	5	—	16.6	(78.4% Cd.)	480	600	4.53
" 071	SN #7	7	85	—	(8% Sn.)	1225	1805	4.82
" TL	TL	9	53	38		1410	1565	4.50
" 202	AT SPECIAL	20	45	35		1315	1500	4.68
" ATT	ATT	20	45	30	(5% Cd.)	1140	1500	4.64
" NE	NE	25	52½	22½		1250	1575	4.71
" 251	AE	25	57.5	17.5		1255	1625	4.68
" SS	SS	40	30	28	(2% Ni.)	1220	1435	4.76
" 404	SS-5	40	30	25	(5% Ni.)	1220	1580	4.72
" DT	DT	40	36	24		1235	1415	4.80
" DE	DE	45	30	25		1230	1370	4.82
" ETX	ETX	50	34	16		1250	1425	4.99
" 541	ALLOY-4772	54	40	5	(1% Ni.)	1340	1575	5.06
" 560	ER	56	22	17	(5% Sn.)	1145	1205	5.00
" 580	EB	57.5	32.5	—	(3% Mn.- 7% Sn.)	1120	1345	5.05
" RT	RT	60	25	15		1245	1325	5.02
" 603	RT-SN	60	30	—	(10% Sn.)	1115	1325	5.23
" 630	RSNI	63	28.5	—	(6% Sn.- 2.5% Ni.)	1275	1475	5.12
" EASY	EASY	65	20	15		1235	1325	5.06
" MEDIUM	MEDIUM	70	20	10		1275	1360	5.14
" BT	BT	72	28	—		1435	1435	5.24
" HARD	HARD	75	22	3		1365	1450	5.28
" 752	TR #1	75	—	25		1300	1330	5.06
" IT	IT	80	16	4		1345	1490	5.29
" 852	85 Ag.-15 Mn.	85	—	—	(15% Mn.)	1760	1780	5.08

*A Solder—Not a Brazing Alloy

Space does not permit listing the many special alloys, formulated for a particular or unique application. Handy & Harman Brazing Engineers and Technical Service are always ready to work closely with you on metal-joining problems and methods.

Comprehensive technical literature covering all aspects of brazing methods and alloys awaits your request.

GET THE FACTS FROM BULLETIN 20

This informative booklet gives a good picture of silver brazing and its benefits...includes details on alloys, heating methods, joint design and production techniques. Write for your copy.

Your NO. 1 Source of Supply and Authority on Brazing Alloys

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Instantaneous Heat

Research story behind luminous wall combustion system for heat treating furnaces.

Holden Metallurgical Products

Circle 114 on postcard for more data

T58 Progress

Current development of T58 aircraft gas turbine.

General Electric Co

Circle 131 on postcard for more data

Welding & Cutting Design

Design features of oxy-acetylene welding and cutting equipment and industrial regulators.

Modern Engineering Co.

Circle 132 on postcard for more data

Fuel Pumps

Centrifugal, high pressure fuel pumps shown for small airplanes, helicopters, military and transport aircraft.

Adel Precision Products

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Electric Connectors

48-pg bulletin describes new line of plugs and receptacles in environment-resistant construction.

Crouse-Hinds Co.

Circle 104 on postcard for more data

Radiation in Industry

12-pg booklet on X-rays and gamma rays for nondestructive inspection and product testing.

Picker X-Ray Corp.

Circle 121 on postcard for more data

Coupling

Described: new quick coupling with steel lock pins for handling industrial liquids, exotic fuels.

Roto-Lock Couplings Inc.

Circle 107 on postcard for more data

Magnesium Alloys

26-pg brochure on magnesium in aircraft.

Magnesium Products Sales Dept.
The Dow Chemical Co.

Circle 98 on postcard for more data

Tape Control

How tape control system works.

Pratt & Whitney Co.

Circle 127 on postcard for more data

Seals-Valves

Bulletin ASO1—bellows seals.
Bulletin HAO2—check valves.

Sealol Corp.

Circle 124 on postcard for more data

Electro-mechanical Equipment

Bulletin 1300 describes motors, actuators, control equipment for aircraft, missiles.

Hoover Electric Co.

Circle 110 on postcard for more data

Stainless Steel Handbook

36-pg book on firm's commercial stainless steel sheet and strip grades, plus corrosion resistance tables.

Washington Steel Corp.

Circle 113 on postcard for more data

Gaseous Oxygen Testing

Story of gaseous oxygen testing of air and spaceborne components and systems.

Whittaker Controls Div.
of Telecomputing Corp.

Circle 128 on postcard for more data

Advanced Data Displays

Description, specifications of display indicators, flight instruments.

Waldorf Electronics

Circle 108 on postcard for more data

Microscopy Accessories

1959 catalog-booklet.

Ernest F. Fullam Inc.

Circle 96 on postcard for more data

Speed Measurement

Line of magnetic-drag tachometer indicators and generators for reciprocating or jet engine aircraft.

General Electric Co.

Circle 117 on postcard for more data

Corro-bags

All-purpose cushioned shipping bag described.

Sherman Paper Products Corp.

Circle 106 on postcard for more data

Magnetic Tape Recorders

Instrumentation bulletins

BJ Electronics
Borg-Warner Corp.

Circle 122 on postcard for more data

Bronze Castings

Reprints of papers on use of bronze castings in the aircraft industry.

Brass & Bronze Ingot Institute

Circle 100 on postcard for more data

Replacement Elements

Engineering data sheet on replacement elements for aircraft main fuel line filters.

Bendix Filter Div.
Bendix Aviation Corp.

Circle 133 on postcard for more data

Shipping Containers

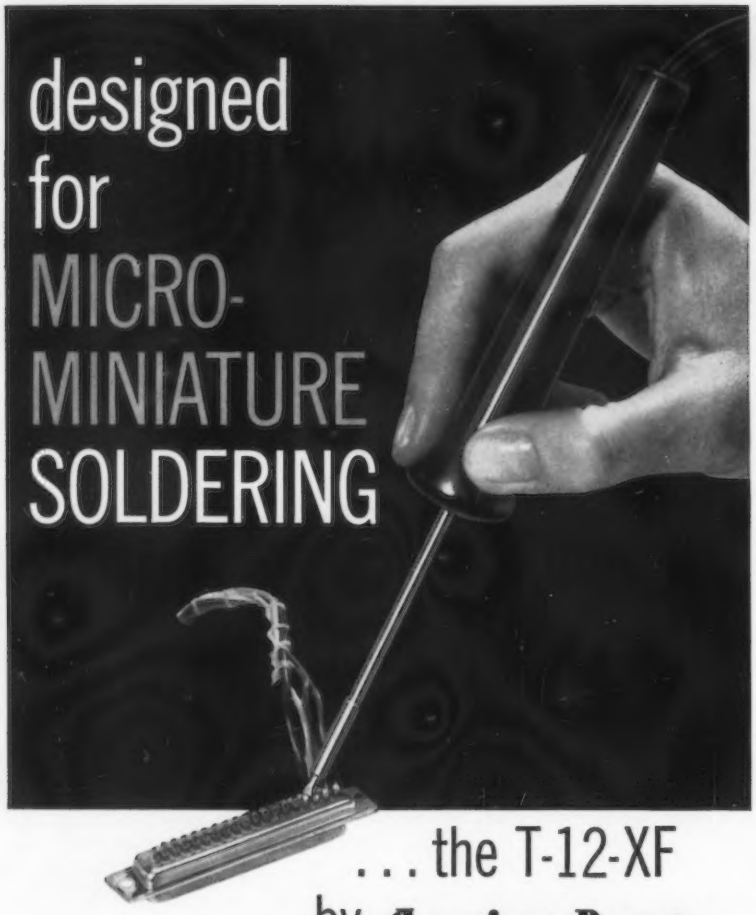
Re-usable steel and aluminum shipping containers illustrated.

DeVilbiss Metal Fabricators Co.

Circle 105 on postcard for more data

continued on next page

designed for MICRO-MINIATURE SOLDERING



. . . the T-12-XF by American Beauty

The T-12-XF Transformer Type Electric Soldering Iron is a scientifically designed, finely engineered tool that is especially intended to do just the kind of soldering job you see being accomplished above.

Proven best-by-test on many similar applications . . . affords extreme flexibility . . . assures a high degree of protection to delicate, expensive electronic components because its hypersil type transformer provides complete line-voltage isolation.

The cord with which the T-12-XF is equipped is ultra-flexible . . . impervious to oil, water and grit.

Tips—elements are Armco ingot iron brazed to stainless steel casings . . . 3/32" (shown), 1/16", 1/8" and 1/4" tip diameters, all same casing diameters.

The featherweight, pencil type handle minimizes operator fatigue . . . is always comfortably cool.

AMERICAN BEAUTY Electric Soldering Irons Are Made In ONE Quality Only . . . The Best . . . And Only The BEST Gives You The MOST!

YOU CAN'T BEAT A SOLDERED CONNECTION

202-B

WRITE FOR 20-PAGE ILLUSTRATED CATALOG CONTAINING FULL INFORMATION ON OUR COMPLETE LINE OF ELECTRIC SOLDERING IRONS—INCLUDING THEIR USE AND CARE.

AMERICAN ELECTRICAL HEATER COMPANY

DETROIT 2, MICHIGAN

worth asking for:

technical literature listed here is available without charge from the various manufacturers

Accessory Equipment

26 pg catalog.

Lyndon Aircraft Inc.

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Rotary Components

Electrical and mechanical information on rotary components.

Clifton Precision Products Co.

Circle 103 on postcard for more data

Armstrong Products

Adhesives, sealers, coatings described.

Industrial Div.
Armstrong Cork Co.

Circle 119 on postcard for more data

Electronic Components

Eight pg folder on relays, solenoids, rectifiers, related components.

Universal Relay Corp.

Circle 102 on postcard for more data

Engineering & Manufacturing

Bulletin 5900-SMD shows how Systems Management Div. works.

Western Gear Corp.

Circle 116 on postcard for more data

Hydraulic Tracer Controls

Catalog.

James Engineering & Machinery Co.

Circle 130 on postcard for more data

Chemical Milled Alloys

Design bulletin no. 8 shows advances in state of art.

U. S. Chemical Milling Corp.

Circle 97 on postcard for more data

Martensitic Stainless Strip Steel

Booklet

Uddeholm Co. of America

Circle 126 on postcard for more data

Cobalt

Second issue of quarterly.

Cobalt Information Center

Circle 101 on postcard for more data

Manufacturing & Welding

Facilities, processes, products of manufacturing firm outlined.

Airline Welding and Engineering Co.

Circle 111 on postcard for more data

Spin Forging

Brochure on spin forging includes description, history, state-of-the-art, equipment (Hufford Model 60V225), effects on materials.

Marquardt Aircraft Co.

Circle 125 on postcard for more data

Thermocouple Systems

Complete data on firm's thermocouple systems for advanced aircraft gas turbine engines.

General Electric Co.

Circle 129 on postcard for more data

Drafting

100-pg drafting equipment and supply catalog.

Alfred Mossner Co.

Circle 109 on postcard for more data

Iochrome

New pure chromium metal described.

Chromalloy Corp.

Circle 115 on postcard for more data

Synchro-Trace

Bulletin describes automatic 3D programmed control system for milling.

True-Trace Sales Corp.

Circle 99 on postcard for more data

Resins

Fast-curing resins for hand lay-up work and premix compounds described. Brochure also on Uraloy 7416 chemical-and-corrosion-resistant resin.

Interchemical Corp. Finishes Div.

Circle 123 on postcard for more data

Koehler Products

Catalog of valves, filters, accumulators for aircraft and missiles.

Koehler Aircraft Products Co.

Circle 120 on postcard for more data

Servo Motors

Fifth edition of 50 pg publication with technical engineering information on servo motors, tachometer generators, motor generators, synchros.

Kearfott Co.

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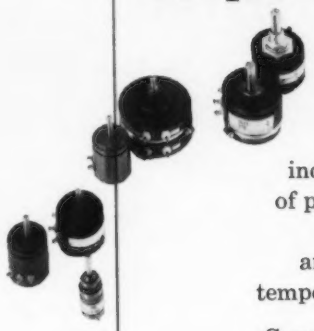
New

Helipot Potentiometer Catalog

HELIPOT POTENTIOMETER LINE



Yours for the asking ...a compendium of the industry's most complete line of precision pots... single-turn and multi-turn... all-metal and economy models... high temperature and standard range.

Complete technical data... even environmental specs... in comparative, tabular form to help you pick the pot that suits your circuit best.

Need associated turns-counting dials... delay lines... trimming pots? They're here too.

Ask for Data File F62

Helipot Division of Beckman Instruments, Inc. Fullerton, California Engineering representatives in 29 cities

potentiometers: dials: delay lines: expanded scale meters: rotating components: breadboard parts

Beckman® / Helipot®

1648

Aircraft engine oil strainer, one of many aircraft, automotive, marine and stationary engine parts cleaned and decarbonized by the new Narda Ultrasonic Vapor Degreaser—in less time and with less chemicals.

NEW!

NARDA Two-Stage, Low-Cost ULTRASONIC VAPOR DEGREASER

- *Better cleaning • up to 40 times faster!*
- *Increases reliability of all engines and systems*

This new production model SonBlaster® Vapor Degreaser, originally designed by Narda for the U. S. Air Force, is now commercially available—and at low cost! Thoroughly and quickly degreases and decarbonizes: oil and fuel strainers, pistons and rings, valves, spark plugs, carburetors, pumps, bearings and parts of all types.

The SonBlaster Vapor Degreaser is simple and economical to use. To degrease: place parts in (1) boiling sump and (2) ultrasonic sump (3) flush with power spray, using filtered and distilled pure solvent (4) condensing solvent vapor removes any residue traces—finished job is the ultimate in degreasing!

For additional information, please write to Dept. AMM-5.

SPECIFICATIONS

Electrical Input: 208/230 volts, 50/60 cycles, 25/20 amps.

Generator: Delivers 300 watts average; 600 watts peak, 40 kc.

Transducer: Barium Titanate, 40 kc. Diaphragm, 112 sq. inches.

Recirculation System: ½ h.p. pump, stainless steel filter; 4500-watt heater, thermostatically controlled.

Valves: Pushbutton, solenoid-operated on all drains.

Cabinet: Cold rolled steel, baked enamel finish; 16 gauge, 302 stainless steel top. (All stainless steel cabinet optional at extra cost.) Over-all dimensions, 56" long x 32" high x 23½" wide.

Sumps: Over-all working area, 28" x 16", 14 gauge, 302 stainless steel, heliarc welded. Boiling sump capacity, 7 gals. Ultrasonic sump capacity, 6 gals. Distillate reservoir capacity, 2 gals.

Price: $2990 for above model. Other Narda Ultrasonic Vapor Degreasers from $1500.

the narda ultrasonics corporation

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Subsidiary of The Narda Microwave Corporation

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PRECISION TUBE BENDING

MB experience ranges from bending simple tubes to fabricating complete assemblies like the fuel manifold shown, and includes machining and bending work with corrosive- and heat-resistant materials.

Extensive facilities devoted solely to tube bending are contained on three factory floors. Equipment includes hydraulic tube benders, presses, automatic and manual brazing and welding equipment.

Aeronautical inspection techniques involve X-ray, Zyglo, Magnaflux, hydraulic and pneumatic pressure testing equipment, when indicated, guaranteeing maximum reliability, performance from parts.

Satisfied customers are included in any list of leading manufacturers in aircraft-missile fields.

Write for MB facilities booklet —or for quotation.

MB MANUFACTURING COMPANY

A DIVISION OF TEXTRON INC., 1069 State St., New Haven 11, Conn.

Circle 46 on Inquiry Card, page 89

where to go for

special

special steels?

TRY J&F—Research/commercial grade special alloy steels from Johnston & Funk—helping corporations bridge R & D production gap.

Close metallurgical control is exercised in producing ingots (to 12" diameter), billets, bars, rod, wire, narrow strip, foil, and special shapes to order. J & F's "Vacutrode"* steels are either single or double vacuum melted and exhibit closely controlled chemistry, low gas content, little or no segregation, and extremely low non-metallic inclusion content.

For fast, flexible service and certified quality, turn to J & F. Write for facilities brochure, catalog, prices, or arrange to meet J & F metallurgists.

*Consumable electrode vacuum melted

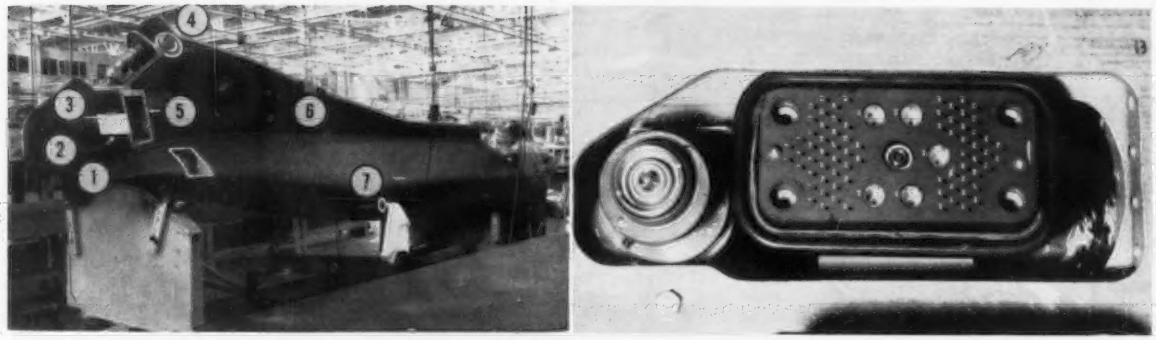
J&F **Johnston & Funk**
METALLURGICAL CORPORATION
WEST KEMROW AVENUE, WOOSTER, OHIO
A subsidiary of Mallory-Sharon Metals Corporation

Examples, Ingot, Bar, Billet, Rod: Carbon steels, low alloy steels, low and high alloy bearing steels, high-speed steels, high-strength steels, high-temperature alloys, and stainless steels.

Examples, Wire: Low alloy, high-strength steels and high-temperature alloys, produced especially for the aircraft and missile industries, paying particular attention to high-surface finish and special packaging.

Circle 47 on Inquiry Card, page 89

industry notes

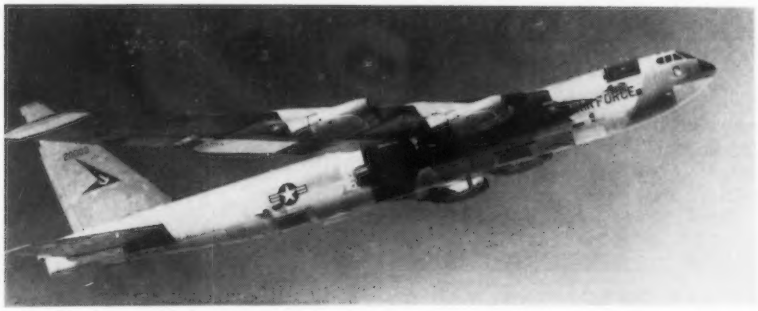


Five ton pylon (left) hangs X-15 beneath B-52's right wing. Umbilical Cannon plug (right) connects power and checkout circuits for aligning X-15's Sperry Gyroscope inertial guidance system before launching. Number key: 1. plug is beneath this forward end of pylon. 2. actuating mechanism for hook holding X-15 to mother ship. 3. access to fwd hook and hook actuating mechanism. 4. lox overboard vent. 5. access to fwd hook linkage and breakaway fittings. 6. access panel to front spar attach fitting. 7. pre-launch lox test vent.

X-15: THE FLIGHTS

LAUNCHING A NEW ERA

X-15 remains tethered to mother ship to 40,000 ft. An 8 x 6 ft. section of B-52's right wing flap was cut out to make room for X-15's tail.



X-15, two million man hours of engineering effort, is held before its shot into space by three hooks in pylon under B-52's right wing. Probably late this month, the hooks will release the research aircraft for its first unpowered glide tests.

While it is tethered by one forward and two side hooks, X-15 is kept alive by feed lines maintaining communication, electrical power, ventilation, heating, breathing oxygen, and auxiliary lox fueling (for powered flights).

Via a single Cannon "umbilical plug," research aircraft's

Now, at your service

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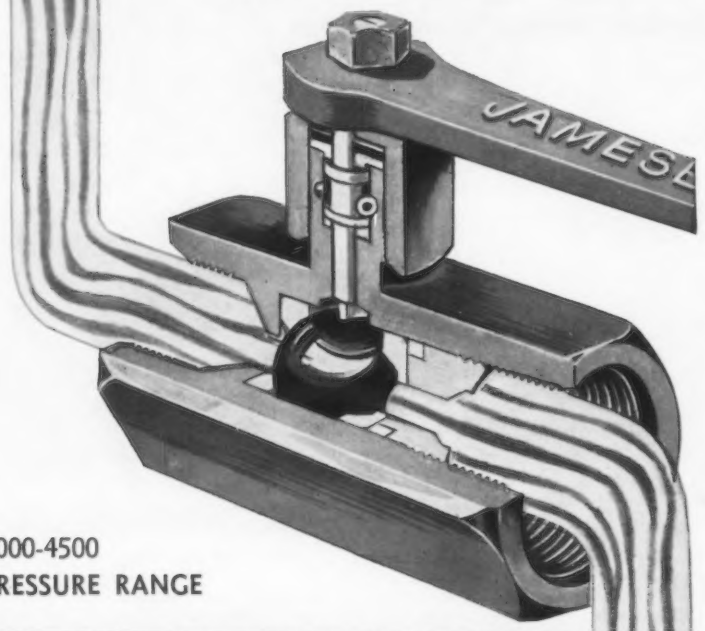
"Double-Seal"™

HIGH-PRESSURE BALL VALVES
STYLE H SERIES

3000 — 4,500 p.s.i. Range



3000-4500
PRESSURE RANGE

. . . outstanding design newly available to industry

for
- High-Pressure service
- High-Vacuum service
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- Cryogenic operations

. . . no other valve has these outstanding features

- Unit-body construction
- Positively leakproof
- Full-flow capacity
- Indestructible in service
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- Contamination-proof
- Incomparable size-rating-test-burst performance ratio

— a newly developed and advanced valve design with broad industrial applications, available in eight sizes — from ¼" through 2" tubing or pipe threads — with 303 and 316 Stainless Steel or Carbon Steel bodies. Choice of nylon or "Teflon" seats and seals.

Distributors in principal cities.
For further information, write: Data: Style "H" Series

225-8

JAMESBURY CORP., 130 NEW STREET, WORCESTER, MASS.

industry notes

Sperry Gyroscope inertial guidance system will be aligned from control panel inserting position and altitude information from B-52's compass and doppler radar systems. Dials monitor the system for malfunctions.

An estimated 85 per cent of X-15's engine cycle is tested before a powered flight begins.

A push of a button in the B-52 and the unique combination of pilot, inertial system and powerplant "drops into space."

Eventual bullet-like powered shot to 100-mile-high altitude will begin with 90 second rocket-impelled thrust, followed by a research flight lasting almost 30 minutes before landing. Controls will not be automatic. Pilot must bring her down by control decisions made on basis of computer information.

The flights will gather data useful to Project Mercury's manned space capsule and the Dyna-Soar orbital craft.

Tucked under B-52 wing, X-15 is vibrated up to frequencies of 30 cycles per sec. Small vibrators on X-15 outer skin showed no harmful resonance between experimental plane, pylon, and B-52.

OUTLOOK FOR MATERIALS

New **compound LC - 800** combining cork and silicone rubber is offered by Armstrong Cork Company's Industrial Div.

Westinghouse Electric Corp. reports that a revolutionary method of growing **germanium crystals** ready for use may lead to outer-space electronic equipment 1,000 times smaller and lighter than present equipment.

The Office of Technical Services reports **metal - reinforced ceramic materials** raise the total load-bearing capability of aircraft radomes. Alumina composites containing wire screen and perforated metal sheets were prepared by hot pressing, phosphate bonding, and ceramic - to - metal brazing. Though composites failed sooner than homogeneous ceramics, the test bars still preserved "considerable structural integrity." Impact absorption of reinforced specimens sometimes was ten times that of ceramic alone.

OTS bulletin PB 151015

AIRFRAME AND WELDMENTS DIVISION

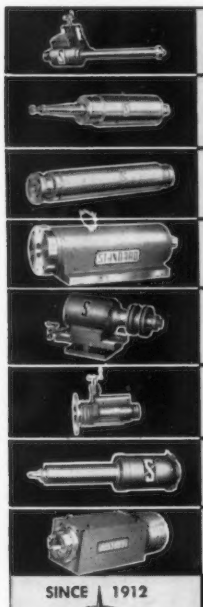
can do it **now** . . . with speed and accuracy!

Complete fabrication, finishing and weldments of ALL metals . . . for ground handling equipment, towers and prefabricated shelters, warehouses and utility buildings used in the aircraft and missile programs.

CHECK WITH MARTIN
and take advantage of our 50 years of development knowhow aimed at furnishing your requirements economically and efficiently.

MARTIN STEEL CORPORATION • MANSFIELD, OHIO

Circle 49 on Inquiry Card, page 89



WHEREVER SPINDLES ARE NEEDED, STANDARD SUPPLIES THE FINEST!

SINCE 1912

the STANDARD electrical tool co.

MAKERS OF 800 DIFFERENT SPINDLES . . . AND READY TO DESIGN 1000 MORE FOR INDUSTRY'S NEEDS!

WRITE TODAY: SUPER PRECISION SPINDLE DIVISION

3000 RIVER ROAD • CINCINNATI 4, OHIO

HALLMARK OF METALWORKING THROUGHOUT THE WORLD

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Keep Hydraulic Circuits in Aircraft and Missiles

CLEAN

with

FERRO-FILTER

Magnetic Separators

Small, compact, ruggedly built permanent magnet separators for removal of steel particles from circulating hydraulic fluids in aircraft and missile fluid power systems. 3000 lbs working pressure; flow from either direction.

the "works"

Liquid flows through stack of steel grids (left) magnetized by two permanent magnets (one shown right). "Honeycomb" design splits fluid stream; fine ferrous particles are caught on the grid edges.

Send for BULLETINS PM-37 and PX-2

S. G. FRANTZ CO., Inc.
Brunswick Pike & Kline Ave.
P. O. Box 1138 Trenton 6, N. J.

Circle 51 on Inquiry Card, page 89

Aeroquip WEBLOCK Straps

SIMPLIFY HANDLING OF ROCKET THRUST CHAMBERS AT ROCKETDYNE

Thrust chambers are palletized for handling.

Use of Aeroquip WEBLOCK Strap Assemblies can solve many materials handling problems. At Rocketdyne, division of North American Aviation, Inc., a simple nylon strap harness was developed to secure top-heavy rocket thrust chambers on pallets. Harness attachment is quick and easy. Tension is automatically locked with a pull of the WEBLOCK Strap, released with finger touch.

Outline your aircraft or missile tie-down requirements and let General Logistics provide simple, low-cost answers. Mail coupon below for details.

Ratchet Tie-Down Buckles

WEBLOCK Strap Assemblies

General LOGISTICS
A DIVISION OF Aeroquip CORPORATION

2929 Floyd Street, Burbank, California
Please send information on: AMM-6
☐ Ratchet Buckle ☐ WEBLOCK Straps
NAME_____
TITLE_____
COMPANY_____
ADDRESS_____
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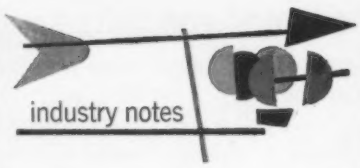
Circle 52 on Inquiry Card, page 89



deals with stabilization of concentrated solutions of **hydrogen peroxide,** with special attention to use of sodium stannate in long term storage of H_2O_2 in aluminum containers.

OTS bulletin PB 151031 reports promising results of Perkin-Elmer Corp. study of a **possible high-temperature-resistant pyrometer** to measure temperatures of combustion gasses in jet engines.

Containers of deep-drawn magnesium have been developed by Zero Manufacturing Co., Burbank, Calif. in collaboration with Dow Chemical Co. Containers have particular electronic applications.

Halocarbon fluorinated greases, used as lubricants in missile propellant systems, are available in milled form from Halocarbon Products Corp. Grease has zinc chromate rust inhibitor.

Defense Materials System, established six years ago, may begin streamlined operation next month as result of conferences between Business and Defense Services Administration and representatives of aircraft and missiles and other industries.

Low cost finishing material for fabricated metals, called "Scotch-Brite," has been developed by Minnesota Mining and Manufacturing Co., St. Paul. Made of nylon web impregnated with fine grades of abrasive mineral, it may also reduce time, costs in the pickling operation.

New **pipe joint sealer** in tape form handles most industrial acids, corrosives, caustics, hydraulic fluids and aromatic fuels. Available from Crane Packing Co., Morton Grove, Ill.

A NEW METHOD FOR WORKING AT HIGH LEVELS SAFELY . . .

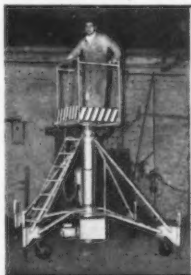
BALLYMORE HYDRAULIC LIFT WORK PLATFORMS

Production and maintenance jobs are made easier, quicker and safer when you use Ballymore Hydraulic Lift Work Platforms. They provide a large, firm working area between 7 and 20 feet from the floor and can be used indoors or out.

Sturdily constructed of steel and mounted on ball-bearing casters . . . can accommodate up to 3 men. Levelizing jacks at each corner assure complete stability.

Hydraulic power raises the formed expanded steel platform to any height up to 15 feet. Double rack and pawl hold the platform at the desired working level.

For complete information, write to the Ballymore Company, West Chester 27, Pa.



MOBILE ACCESS LIFTS . . .

For working levels up to 40 feet above ground level. Easily positioned, quickly elevated, safe. May be collapsed for mobility through restricted openings. Invaluable for a variety of jobs. Write for details.

LOOK FOR THIS LABEL TO BE SURE IT'S THE BEST!

BALLYMORE COMPANY WEST CHESTER, PA.

Circle 58 on Inquiry Card, page 89

AIR FORCE ROCKET POWER

with pressure vessels by Butterworth in the instrumentation and launching systems

In the launching system for the Air Force's Bomarc, pressure vessels custom-designed and custom-built by Butterworth assure precise volumetric control of liquid nitrogen.

Pressure vessels by Butterworth meet the most rigid requirements for high and low temperature operation. Butterworth experience in the design and building of molds for Naval solid propellants is also available to prime contractors in the missile and rocket field.

Talk to a Butterworth engineer. Or write for "The Butterworth Story", a quick-tour of our complete metalworking facilities.

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Metalworking for Industry Since 1820

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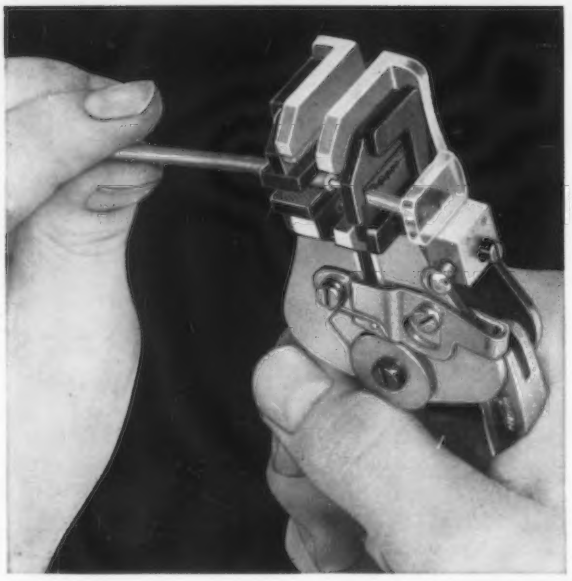


Just One Squeeze with IDEAL's New "Custom Stripmaster" Removes Teflon* and Other Hard-to-Strip Insulations

To help prevent wire nicking and insulation damage, these new IDEAL "Custom Stripmasters" are precision drilled on watchmaker's equipment.

With Ideal's new Custom Stripmasters, a light squeeze on the handles strips any wire completely clean and bare up to a full ⅞ inch.

To help prevent nicking and scraping of wires, the Custom Stripmaster's matched sets of blades are precision drilled on watchmaker's equipment to the exact wire sizes. Counterbored blades ride on cut insulation to prevent scratching of stripped wire. Jaws grip wire firmly to prevent insulation damage. 3 models available. Wire sizes from No. 10 to 30.

*Reg. Trademark of DUPONT

Custom Stripmaster®
Patented, No. 2,523,936
by IDEAL

IDEAL INDUSTRIES, Inc.
1390-F Park Avenue, Sycamore, Ill.

Gentlemen: Please send catalog information on IDEAL's New "Custom Stripmaster."

Name_____
Company_____
Address_____
City_____ Zone____ State_____

Circle 54 on Inquiry Card, page 89

* Package with Confidence

New Mystik Brand Super Flextron® Tape No. 6497 Has Bi-Directional Strength

An unique packaging tape. Super strength bi-directional filaments are an integral part of the product—providing equal strength in both directions. The tape is water and moisture proof. Excellent quick stick properties and it stays stuck.

TYPICAL APPLICATIONS: Strapping and holding heavy machinery parts—sealing heavy-content packages for shipment—holding loose parts in place for assembly of refrigerators and stoves—heavy banding on corrugated, fiberboard and wooden cartons—strapping tubes, rods and lumber—banding groups of cartons on pallets. Frequently replaces steel strapping.

(Conforms to Government Specifications PPP-T-97-Type 11)

Write for full information on Mystik Super Flextron No. 6497 and other Mystik brand packaging tapes.

Mystik Adhesive Products, Inc.
2635 N. Kildare Ave.,
Chicago 39, Illinois

MYSTIK BRAND TAPES
SELF-STIK

PROTECTIVE COVERING MATERIALS—TAPES THAT TALK

Circle 55 on Inquiry Card, page 89

THE Staplex
HI-VOLUME AIR SAMPLER
for your most exacting requirements

FOR INDOOR OR OUTDOOR SAMPLING

Accurately samples to 1/100 of a micron . . indispensable for series or unit sampling . . portable . . inhales an entire area.

Used to measure air pollutants such as radioactive material, chemical dusts, smoke and smog, and in geodetic surveys, missiles research, mining, factory safety programs, plant and insurance inspections, etc.

Write for new brochure

THE Staplex CO.
AIR SAMPLER DIVISION

777 FIFTH AVENUE
BROOKLYN 32, N.Y.
Dept. A-1

Circle 24 on Inquiry Card, page 89

FACILITIES

Hexcel Products Inc. is expanding its Berkeley, Calif. facility about 20% by leasing a 20,000 sq. ft. adjoining building.

U. S. Radium Corp. has moved its entire tritium production operation to a new one-story facility adjoining its Bloomsburg, Pa. plant.

The Fairchild Astrionics Div. has enlarged its sales, contracts, and service operations and combined them into one department.

Babcock Radio Engineering added a 25,000 sq. ft. production building to Costa Mesa, Calif. facilities.

Aeronutronic Systems, Inc. plan a second 120,000 sq. ft. building for its Space Technology Div. and an environmental test building for use by all divisions. Full occupancy of a 120,000 sq. ft. building by the Computer Div. is expected this month.

Newly formed **Goodrich-High Voltage Astronautics Inc.**, Burlington, Mass., specializes both in R & D and manufacture of ion propulsion devices.

New **PAM Associates, Inc.**, Baltimore, will design and build equipment to test effects of shock and vibration and for noise control.

Air Products Inc., Allentown, Pa., will build a $6-million facility near Pittsburgh for production and distribution of high purity liquid oxygen, liquid nitrogen and liquid argon.

Recently dedicated: **Avco Manufacturing's** $23-million six building Research and Development Center, in Wilmington, Mass.

An Advanced Product Planning group has been established at **Hamilton Standard**, div. of United Aircraft Corp.

Electronic Controls Div. of **General Controls Co.** is now located in new building in Burbank, Calif.

Induction Motors Corp. has changed its name to **IMC Magnetics Corp.** It has acquired Gray & Kuhn Inc., Roslyn Heights, L. I., as a new division and is doubling the size of the IMC Westbury, L. I. plant.

Under construction at **Edwards Air Force Base**, Calif.—rocket engine test stand for liquid propellant 1,500,000-lb-thrust rocket engines being developed by Rocketdyne.

Temco Aircraft Corp. will begin building a 250,000 sq. ft. climate-controlled addition at Garland, Texas for precision work on components for missiles and other space age units. Temco has formed new Electronics Div. and separate Missiles and Aircraft and Aircraft Overhaul and Modification Divisions.

NRC Equipment Corp., has set up a West Coast engineering office at Palo Alto, Calif.

Linde Co. is beginning operation of first section of multi-million-dollar oxygen-nitrogen producing plant at Pittsburg, Calif.

The Gabriel Co. is expanding into space age activity by constructing $1-million first plant section of large manufacturing plant for production of solid fuel. Located at Mesa, Ariz., plant will produce fuel for moderate thrust rockets and missiles. It will be operated by Rocket Power Inc., Gabriel's wholly owned subsidiary.

Aeronca Mfg. Corp. has acquired by merger Longren Aircraft Co., Torrance, Calif. Latter will continue to manufacture aircraft components as Aeronca's Longren-California Div.

Alleghany Ballistics Laboratory is installing a 25-million volt betatron for X-ray examination of solid propellant for Polaris. The betatron, manufactured by Allis-Chalmers Mfg. Co., will be first of its type in the missile field.

Piasecki Aircraft Corp. is moving towards greater diversification by new Mayfield Electronics Div., Mayfield, Pa. Facility includes 65,000 sq. ft. of manufacturing area.

New Systems research activity is functioning at La Jolla, Calif. for Defense and Technical Products Div. of **Rheem Manufacturing Co.** One of chief avenues of approach: applied research in the mathematical phase of complex problems.

Hughes Aircraft Co. is now operating a complete service of planning, designing, engineering and constructing radiation facilities and radiation laboratory equipment.

New international subsidiary of **Lockheed Aircraft**, to be known as Lockheed Aircraft International, will develop coordinated aviation programs abroad.

Cessna Aircraft Co. doubles size of Hutchinson, Kan. plant in planned 158,000 sq ft expansion of Industrial Products Div.

work in the fields of the future at NAA

STRUCTURAL TEST ENGINEERS

NAA has immediate openings for senior engineers to work on such top-level projects as the B-70, F-108 and the rocket ship X-15.

As part of our expanding organization, you'll manage elevated temperature test projects, including planning and design; conduct tests and report results.

INSTRUMENTATION ENGINEERS

If you know instrumentation and equipment limitations, and are experienced in the design of setups, there is a career for you measuring strains, static and dynamic loads, temperatures and deflections.

Write to: Mr. L. F. Stevenson, Engineering Personnel, North American Aviation, Inc., Los Angeles 45, California.

THE LOS ANGELES DIVISION OF
NORTH AMERICAN AVIATION, INC.

CONTRACTS

Douglas Aircraft is prime contractor for 12 "Delta" launching vehicles slated for use in 1960 and 1961. The $24,067,500 NASA contract looks to Delta (same 3-stage configuration as Thor Able, plus improved guidance) as interim vehicle until larger boosters are developed.

The Air Force picked Douglas to design the "Bold Orion" ballistic air - to - surface missile. No dollar value was disclosed on the contract.

NASA awarded Convair Div. of General Dynamics $33.5-million contract to design, build, test and launch Vega-advanced booster for lunar and planetary investigations. First test flights are expected late next year.

The Army's lightweight surface - to - surface missile for close-in troop support, "Shillelagh," will be developed by Aeronutronic Systems Inc., Glendale, Calif. Operational date: about mid-1960's. Total contracts to firm are expected to run about $23-million.

Bendix Aviation received $28.3-million Navy contract for Talos production, two other Navy contracts totaling $12.9-million for missile engineering and procurement of prototype missiles.

The Army awarded Western Electric Co. $8,671,000 for research and development on Nike Zeus. Work will take place at Bell Telephone Labs, Whippany, N. J.; Douglas Aircraft, Santa Monica; Continental Can Co., Coffeeville, Kan.; and Goodyear Aircraft, Akron, O.

Other missile contracts all from NASA went to Bell Aircraft, $1,200,000 to continue studies on high-energy rocket propellants; Chance Vought Aircraft, $945,000 to build airframe of Scout rocket and integrate its four solid rocket stages; General Electric, $4.12-million for Project Vega second stage rocket engine; North American Aviation, $930,000 for destruct system for Project Mercury and design of its ground support transport vehicles and launchers. Radio-plane Div., Northrop Corp. received $60,000 for Mercury's landing and recovering system.

General Chemical Div., Allied Chemical, received $750,-000 from ARGMA for research on high energy oxidizers for advanced solid rocket propellants. Army gave Longhorn Div., Thiokol Chemical Corp., $11,900,165 for rocket motors and plant maintenance.

In aircraft contracts, the Navy awarded the Martin Co. $15,400,000 to modernize 28

D-C POWER

Precisely Regulated for Missile Testing and General Use

CHRISTIE

SILICON POWER SUPPLIES

available in 30 standardized and militarized models from 30 to 1500 amps... 6 to 135 volts. CHRISTIE'S QUALITY CONTROL is approved by the A.E.C., leading aircraft and missile manufacturers.

Write For Bulletin AC-58-A

CHRISTIE ELECTRIC CORP.
3410 W. 67th Street
Los Angeles 43, Calif.

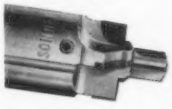
Circle 56 on Inquiry Card, page 89

"A.N.D." and "M.S." HYDRAULIC CONTOUR CUTTERS in stock

A.N.D. 10050 internal

Economy series; integral plain pilot

Turret lathe and drill press series; integral carbide reamer pilot



Heavy duty series; replaceable carbide reamer or plain pilot, carbide and HSS

MS33656, MS33657, MS33514, and MS33515 O.D. flat form tools

Carbide tipped High speed steel

MS33514 internal

Solid carbide, carbide tipped, high speed steel models

MS16142 internal S.A.E.

Carbide tipped; plain or reamer pilot

Write for sizes and prices.

SONNET Tool and Mfg. Co.
571 North Prairie Avenue, Hawthorne, California

Circle 57 on Inquiry Card, page 89

P5M-2 ASW patrol seaplanes at the Baltimore Div. North American Aviation received a $19,300,000 Navy follow-on contract for production of T2J-1 basic jet trainers at Columbus, O. Cleveland Pneumatic Industries received multi-million-dollar contracts from North American Aviation to develop and manufacture the landing gear for the B-70 bomber and the F-108 long-range interceptor. The landing gear projects will involve firm's divisions at Cleveland, Kalamazoo, and Grand Rapids, Mich., plus the Advanced Systems and Development Div., El Segundo, Calif.

The Air Force awarded Douglas Aircraft a $600,000 contract to develop Douglas's Materials Handling Support System. Douglas will work with I. B. M. and Arthur D. Little on the nine month project.

Westinghouse Electric Corp. received $2-million development contract from ARDC's Wright Air Development Center for research to design miniaturized electronic equipment from uniform flat germanium crystal ribbons "growing" in exact shape for use.

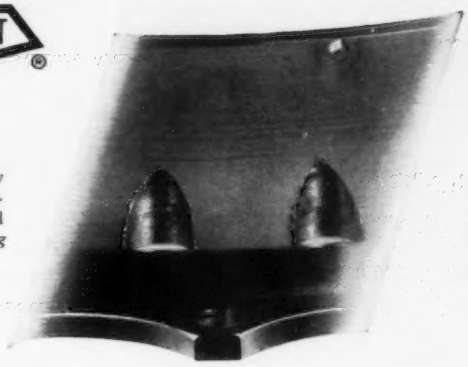
TRIPLES THRUST . . .

Large-scale production of liquid hydrogen is underway under Air Force contract by Air Products Inc., and Stearns Roger Manufacturing Co.

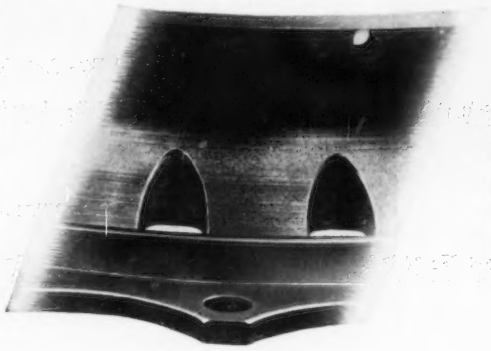
PICKS PICKABACK . . .

The Assistant Chief Engineer of Bristol Siddeley Engines Ltd. reports that a project study shows a two-stage "pickaback" aircraft reaching Mach 7 merits "serious consideration." First stage 240,000 lb aircraft would launch 160,000 lb hypersonic stage at Mach 4 and 90,000 ft. Latter would reach Mach 7 and 140,000 ft.

OSBORN®



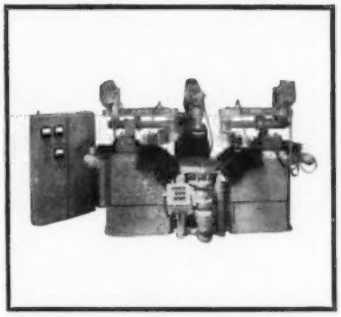
BEFORE BRUSHING
Jet engine part formerly hand-filed and emery-rubbed to remove burrs and sharp edges. *Hand-finishing time: 45 minutes.*



AFTER BRUSHING
Burrs thoroughly removed... edges and surface junctures blended to 6-8 microinches. Each part precision-finished quickly, uniformly. *Osborn Brushamatic® finishing time: 6 minutes.*

6 minutes to microfinish this jet engine part!

...it's 7½ times as fast with OSBORN Brushamatic® Methods



THESE JET ENGINE PARTS are microfinished at low cost, automatically—at high production rates on Osborn Brushamatic® 51-3L Machine. Three Osborn Fascut® brushes (with compound) operating at 1750 rpm do the job.

IT used to take 45 minutes to hand-finish this precision jet engine component. *Today, this leading jet engine manufacturer does the job in just 6 minutes with Osborn Brushamatic® Methods. It's 7½ times as fast and results in significant dollar savings.*

Slow hand-finishing still left scratch marks to cause possible stress fractures. But, rapid Brushamatic® finishing produces a *precision 6 to 8 microinch surface* . . . automatically removes burrs . . . blends sharp edges and surface junctures.

Result: a fast, economical, precision Brushamatic® finish that reduces stress concentration areas. Uniform, high-quality parts are produced at high production rates.

It's typical of how Osborn Power Brushing works to help you speed production . . . cut costs . . . improve product quality. An Osborn Brushing Analysis, made in your plant at no obligation, will show you how. Write or wire us for details —and for your copy of the 20-page Brushamatic® booklet. *The Osborn Manufacturing Company, Dept. AM-5, Cleveland 14, Ohio.*

Osborn Brushes

BRUSHING MACHINES • BRUSHING METHODS
POWER, PAINT AND MAINTENANCE BRUSHES • FOUNDRY PRODUCTION MACHINERY

work in the fields of the future at NAA

STRUCTURES ENGINEERS

Exceptional opportunities are available for Structures Engineers on our B-70 and F-108 weapon systems and X-15 manned space aircraft.

Stress Analysis—Rigorous design requirements necessitate extensive structural investigation of the influence of high temperatures and unconventional external loadings. Stress engineers concerned with such structures will have the opportunity to utilize their technical knowledge to the fullest extent in the development of new analysis methods.

Load Analysis—Corresponding demands on the structural loads engineer have also created unique careers with significant potential in the fields of dynamic loads, aeroelastic loads, loading spectra, flight load data analysis, and digital and analog computer programming.

Weight Analysis—Exacting air vehicle performance requires the optimization of structural design layouts to produce the lightest weight configurations. Weight engineers with experience in stress analysis are required for the formulation of advanced weight estimation and control procedures.

For details about these positions please write: Mr. L. F. Stevenson, Engineering Personnel, North American Aviation, Inc., Los Angeles 45, California.

THE LOS ANGELES DIVISION OF

NORTH AMERICAN AVIATION, INC.

TERRA-SCOPE

Spacesuit for X-15 pilot, primarily for protection in emergency escape, was put together with new, classified manufacturing method. Aluminized suit, which allows easy movements and only pressurizes if cabin depressurizes, was developed by David Clark Co. for Aero-medical Lab at WADC. Back Pack manufactured by Firewel Co., Buffalo, N. Y., is only 15 in. x 17 in., 1¼ in. thick. This would regulate oxygen pressure in suit in emergency. Present contractor for space helmet: Bill Jack Scientific Instrument Co., Solana Beach, Calif.

•

Bell Aircraft's unique reaction control system for X-15 will also be used for Mercury space capsule.

•

Details of the Bell system: Silver screen catalyst decomposes hydrogen peroxide to provide steam jets for wing-tips and nose. Replacing aerodynamic controls when X-15 bursts beyond earth's atmosphere, system was first tested successfully in Bell X-1B for NACA at Edwards Air Force Base. Bell manufactures thrust chamber assembly, composed of chamber, check valves and the catalyst assembly.

•

X-15 program may last as long as five years with repeats of 100-mile high shot which should take place about the middle of next year.

•

Highly miniaturized amplifiers are uniquely designed within the gimbal structure of X-15's inertial guidance platform instead of in a separate amplifier rack, as with more conventional systems. Instead of a "black box," computer is white, as is gimbal structure.

•

18 lb heater to protect engine fuel against icing has been developed by AiResearch Manufacturing Div. of the Garrett Corp. It uses hot engine compressor bleed air ducted through air-to-liquid heat exchanger.

•

Federal German Republic will manufacture under license the Bristol Siddeley Orpheus 803 turbojet engine. It is powerplant of the Fiat G-91, also to be manufactured in Germany under license as standard NATO tactical strike fighter.

•

Lockheed Aircraft is prime contractor for first operational monorail system for mass urban transportation. The $5-million system, including three "airtrains," will be part of Seattle's Century 21 exposition opening May, 1961. Lockheed design uses aircraft weight economies for vehicles mounted on rail above street.

•

Price tag on air-launched Genie rocket: $234,000 for warhead, $7,000 for carrying vehicle.

•

First Hawk unit will be activated at Fort Bliss, Texas this month.

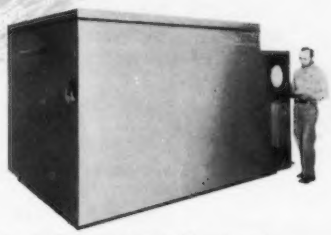
•

First step has been achieved in establishing basis for interchange of costly engineering data among the military departments and their contractors, Uniform specifications (MIL-D-70327), developed by DOD and industry, replaces 158 specifications formerly used in military procurement.

•

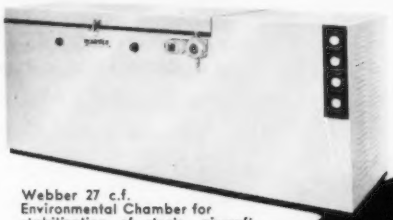
Ryan Aeronautical's KDA-4 Firebee jet drone is now operational.

WEBBER ENVIRONMENTAL CHAMBERS—YOUR ASSURANCE OF RELIABLE PERFORMANCE

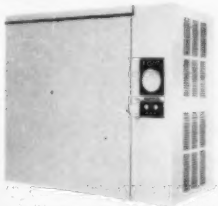


Webber 360 c.f. Environmental Chamber for processing stainless steel honeycomb with convection fluid.

Webber 36 c.f. Altitude Chamber. Temperature —130°F to +350°F; Altitude 0 to 150,000'; Relative Humidity 20 to 95%.



Webber 27 c.f. Environmental Chamber for stabilization of steels, aircraft component testing, calibration of instruments, transformation of austenite to martensite, nuclear radiation testing, shrink fitting, processing and storage of solid fuels.

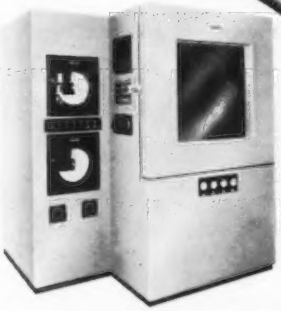


Webber 576 c.f. Environmental Chamber. Inside dimensions 12' x 8' x 6' for storage of aluminum sheets and components to prevent age hardening.

FINEST *performance*

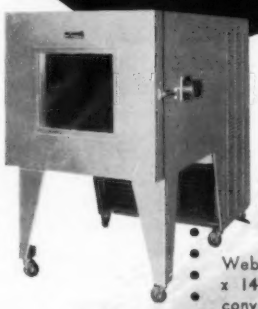
MAXIMUM *versatility*

HIGHEST *quality*

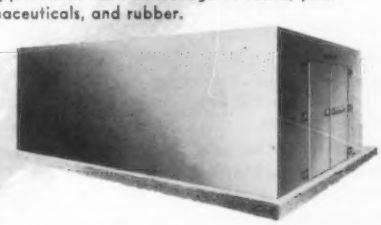


Webber 12 c.f. Environmental Chamber for testing diodes and electronic components. Sufficient capacity to process 90 lbs. of diodes from +355°F to —65°F in 30 minutes with programmed repeated cycles. Available in other sizes, temperature ranges and humidity.

Webber 50 Canister Rivet Cooler. Temperature range from ambient to —50°F. Other applications such as storage of resins, pharmaceuticals, and rubber.



Webber Portable Environmental Chamber for vibration units. Temperature range —125°F to +500°F. Inside dimensions 24" x 26" x 24". Other sizes and temperature ranges available.



Webber 2,940 c.f. Environmental Chamber. Inside dimensions 30' x 14' x 7' for processing stainless steel honeycomb, using air convection.

Webber Environmental Chambers available in any size with combination temperature ranges to —225°F, utilizing mechanical refrigeration. Heating cycle and explosion proof features optional.

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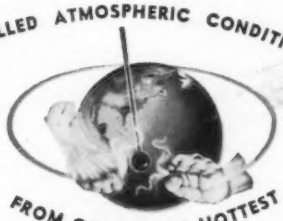

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june 5-6
annual meeting
army aviation assn. of america
shoreham hotel, washington, d.c.

✦

june 8-11
semiannual meeting and
astronautical exhibition
american rocket society
el cortez hotel, san diego, calif.

june 12-21
23rd french international air show
le bourget, paris

✦

june 14-18
semiannual meeting
american society of mechanical
engineers
chase-park plaza hotel, st. louis

june 16-17
industry, missile and space conference
michigan aeronautics and space asso.
sheraton-cadillac hotel, detroit

✦

june 16-18
symposium on solid propellants
AFOSR/Aeronautical Sciences
Directorate, ONR, OOR
washington, d.c.

✦

june 16-19
national summer meeting
institute of the aeronautical sciences
ambassador hotel, los angeles

✦

june 23-25
33rd meeting
aviation distributors and
manufacturers assn.
st. francis hotel, san francisco

✦

august 31-sept. 5
10th annual congress
international astronautical federation
church house, westminster, london

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index to advertisers

This Advertisers' Index is published as a convenience, and not as part of the advertising contract. Every care will be taken to index correctly. No allowance will be made for errors or failure to insert.

AMP Inc. 1
Acoustica Associated, Inc. 64
Airetool Mfg. Co. 70
Air Reduction Sales Co. 35
Amchem Products, Inc. 39
American Brakeshoe Co. 38
American Electrical Heater Co. .. 74

Baldwin - Lima - Hamilton (Electronics & Instrumentation Div.) 51
Ballymore Co. 80
Barco Mfg. Co. 66
Beckman Instrument Inc. 75
Black, Silvalls & Bryson Inc. 48
Brunswick-Balke-Collender Co. .. 4
Buckeye Tools Corp. 60
Budd Co. (Tatnall Measuring Systems Co.) 36
Butterworth Div. Van Norman, Ind., Inc. 81

Chicago Pneumatic Tool Co. 18-19
Christie Electric Corp. 84
Clearing Div. of U. S. Industries, Inc. ..... Back Cover
Colonial Rubber Co. 17
Convair Div. 71
Curtiss-Wright Corp. 58

Dynapak Div. of Convair 71

Elastic Stop Nut Corp. of America 59
Electronic Specialty Co. Inside Front Cover

Frantz Co., Inc., S. G. 79

General Electric Co. Flight Propulsion Div. 63
General Logistics Div. Aeroquip Corp. 80

Hamilton Tool Co. 50
Handy & Harman 72
Hi-Shear Rivet Tool Co. 13
Hufford Corp. 68

Ideal Industries, Inc. 82

Jamesbury Corp. 78
Johnston & Funk Metallurgical Corp. 76

La Vezzi Machine Works 70
Leonard, Inc., Wallace O. 25
Lindberg Engineering Co. 54-55
Linde Co. Div. UCC Electric Welding 37
Flame Plating 33

MB Mfg. Co. 76
Martin Co. 52-53
Martin Steel Corp. 79
Matthews & Co., Jas. H. 3
Misco Precision Casting Co. 56
Mystic Adhesive Products, Inc. .. 82

Narda Ultrasonics Corp. 76
North American Aviation Inc. .. 83, 86

Osborn Mfg. Co. 85

Pure Carbonic Co. 40
Purolator Products Inc. Inside Back Cover

Raybestos-Manhattan Inc. (Reinforced Plastics Dept.) ... 62
Rolle Mfg. Co. 41

St. Louis Car Co. 45
Sidney Machine Tool Co. 30-31
Snap-Tite 61
Sonnet Tool & Mfg. Co. 84
Standard Electrical Tool Co. 79
Staplex Co. 82

Tatnall Measuring Systems Co. .. 36
Taylor Fibre Co. 67

Victor Equipment Co. 34

Webber Mfg. Co. 87
Wyman-Gordon 65

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Circle 2 on Inquiry Card, page 89

Circle 3 on Inquiry Card, page 89 ——→

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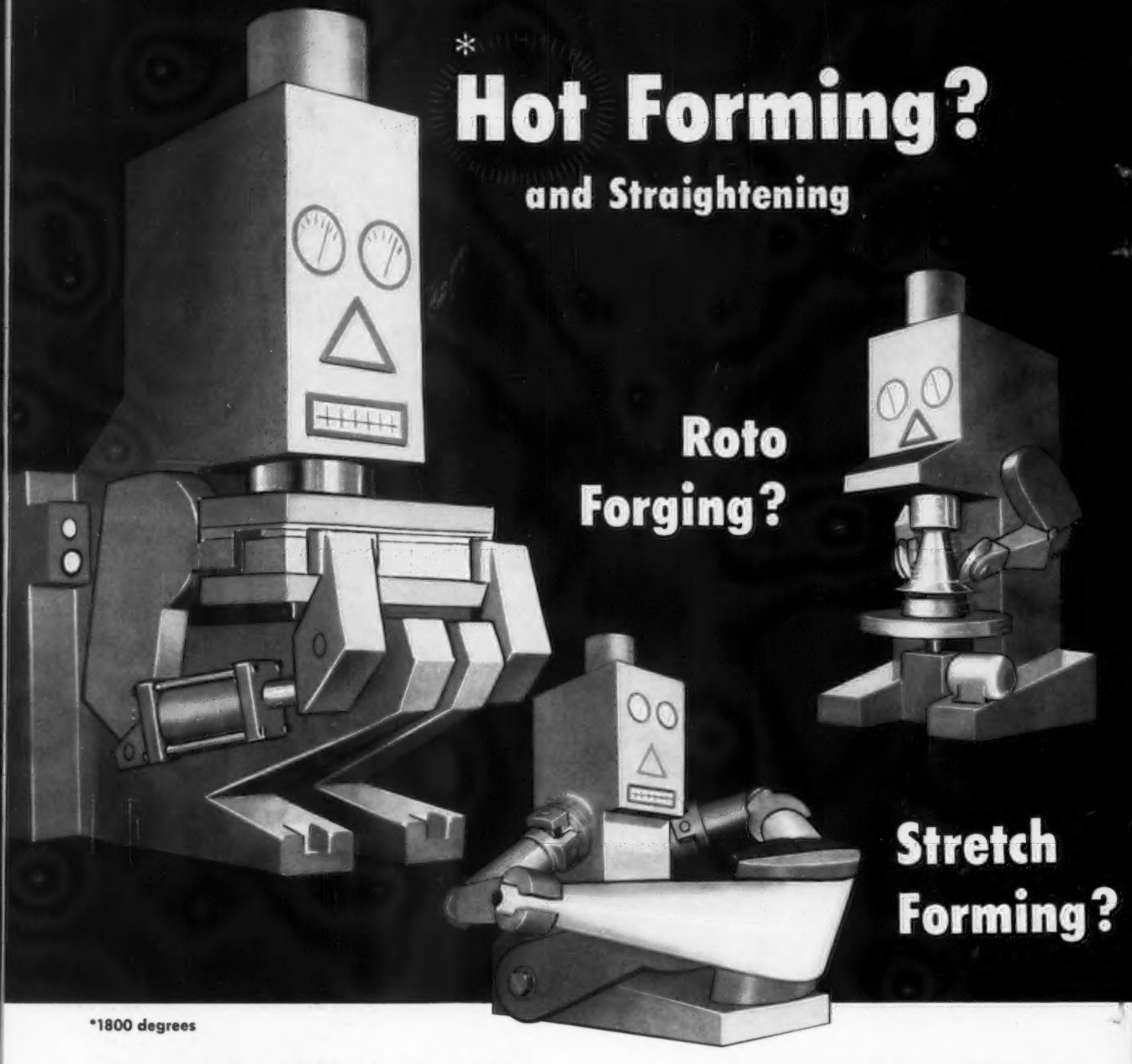

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